WMP-27020
Revision 0

Borehole Summary Report for Characterization Borehole C4545 Drilled at the 216-A-8 Crib

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200

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J. D. Aardal 6/12/2006
Release Approval Date

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TERMS

bgs	below ground surface
BH	borehole
CIN	container identification number (scannable barcode)
counts/min	counts per minute
CWCSA	Central Waste Container Storage Area
GM	Geiger-Mueller (radiation counter)
HEIS	*Hanford Environmental Information System* database
ID	identification
IDW	investigation-derived waste
MDL	minimum detection level
MSW	miscellaneous solid waste
N/A	not applicable
NPH	normal paraffin hydrocarbons (refined kerosene)
OU	operable unit
OVM	organic vapor monitor
PAM	portable alpha meter
PIN	primary drum identification number (written number)
ppm	parts per million
PUREX	Plutonium-Uranium Extraction (process)
RA	Radiation Area
RMA	Radioactive Materials Area
RCT	radiological control technician
REDOX	Reduction-Oxidation (process)
RI/FS	remedial investigation/feasibility study
TOC	top of casing
TWA	time-weighted average

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METRIC CONVERSION CHART

Into Metric Units

If You Know	*Multiply By*	*To Get*
Length		
inches	25.4	Millimeters
inches	2.54	Centimeters
feet	0.305	Meters
yards	0.914	Meters
miles	1.609	Kilometers
Area		
sq. inches	6.452	sq. centimeters
sq. feet	0.093	sq. meters
sq. yards	0.0836	sq. meters
sq. miles	2.6	sq. kilometers
acres	0.405	Hectares
Mass (weight)		
ounces	28.35	Grams
pounds	0.454	Kilograms
ton	0.907	metric ton
Volume		
teaspoons	5	Milliliters
tablespoons	15	Milliliters
fluid ounces	30	Milliliters
cups	0.24	Liters
pints	0.47	Liters
quarts	0.95	Liters
gallons	3.8	Liters
cubic feet	0.028	cubic meters
cubic yards	0.765	cubic meters
Temperature		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius
Radioactivity		
picocuries	37	Millibecquerel

Out of Metric Units

If You Know	*Multiply By*	*To Get*
Length		
millimeters	0.039	inches
centimeters	0.394	inches
meters	3.281	feet
meters	1.094	yards
kilometers	0.621	miles
Area		
sq. centimeters	0.155	sq. inches
sq. meters	10.76	sq. feet
sq. meters	1.196	sq. yards
sq. kilometers	0.4	sq. miles
hectares	2.47	acres
Mass (weight)		
grams	0.035	ounces
kilograms	2.205	pounds
metric ton	1.102	ton
Volume		
milliliters	0.033	fluid ounces
liters	2.1	pints
liters	1.057	quarts
liters	0.264	gallons
cubic meters	35.315	cubic feet
cubic meters	1.308	cubic yards
Temperature		
Celsius	multiply by 9/5, then add 32	Fahrenheit
Radioactivity		
millibecquerel	0.027	picocuries

1.0 INTRODUCTION

This report summarizes the characterization activities performed at the 216-A-8 Crib as part of the remedial investigation for the 200-PW-3 Organic-Rich Process Condensate/Process Waste Group Operable Unit (OU). The 216-A-8 Crib is a representative waste site for the 200-PW-3 OU. Characterization was conducted in accordance with the sampling and analysis plan in DOE/RL-2001-01,*Plutonium/Organic-Rich Process Condensate/Process Waste Group Operable Unit RI/FS Work Plan, Includes: 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units*, Appendix B.

Characterization activities included drilling borehole C4545 at the 216-A-8 Crib in June 2005 using cable-tool drilling equipment to collect soil samples for chemical, radiological, and physical properties analyses, define the stratigraphy beneath the waste site, and determine the nature and vertical extent of contamination. Activities conducted at the 216-A-8 Crib to provide information to select the location for borehole C4545 included soil-vapor sampling in the shallow vadose zone using a direct-push technology for subsurface access, soil-vapor sampling in the deep vadose zone using existing wells for subsurface access, and geophysical logging of existing wells.

Characterization results presented in this report will be used as supporting information for the remedial investigation report prepared as part of the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* remedial investigation/feasibility study (RI/FS) process. Drilling and sampling activities described in this report provide information that can be used to refine the preliminary conceptual contaminant-distribution model, support an assessment of risk, and support evaluation of a range of remedial alternatives for this waste site.

Borehole C4545 was decommissioned in July 2005 after the drilling, sampling, and geophysical logging activities were completed.

The location of the 216-A-8 Crib is shown in Figure 1-1.

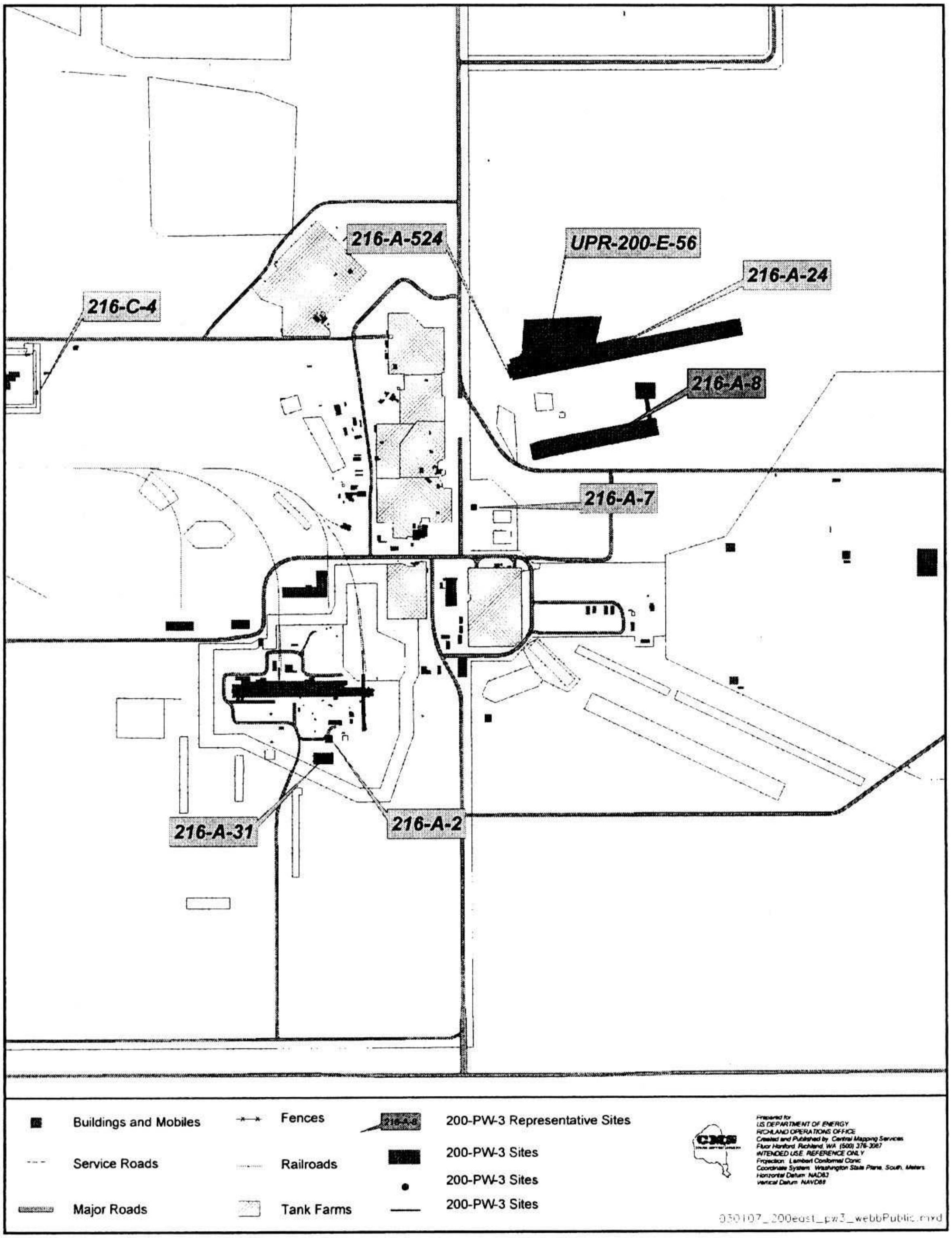
Key documents supporting these remedial investigation field activities include the following:

- DOE/RL-2001-01, *Plutonium/Organic-Rich Process Condensate/Process Waste Group Operable Unit RI/FS Work Plan: Includes the 200-PW-1, 200-PW-3,and 200-PW-6 Operable Units*

- CP-15371, *Remedial Investigation Data Quality Objectives Summary Report for the Plutonium/Organic-Rich Process Condensate/Process Waste Group Operable Unit Representative Waste Sites*

- WMP-20501, *Waste Control Plan for the Plutonium/Organic-Rich Process Condensate Waste Group Operable Unit: Includes the 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units.*

Figure 1-1. Location of the 216-A-8 Crib in the 200 East Area.



1.1 PURPOSE AND SCOPE

This report compiles information and data associated with fiscal year 2004 and fiscal year 2005 field activities that included drilling and sampling of one characterization borehole (C4545), soil-vapor sampling at five locations using the GeoProbe, a direct-push technology, for subsurface access (Appendix A, conducted July 2004); soil vapor sampling of five existing wells (Appendix B, conducted April 2005); and geophysical logging of six existing wells (Appendix C, conducted April through July 2004). This report includes descriptions of borehole drilling and decommissioning, soil-vapor sampling methods and results, geophysical logging reports, and a summary of field activities associated with borehole C4545. Additional information described in this report includes civil survey results, a summary of soil-sample-collection activities, field-screening results for soil samples and drill cuttings brought to the surface during drilling, and subsurface geologic descriptions. All drilling data in this report are provided using field measurement units. Metric and English equivalencies are available in the conversion chart at the beginning of this document.

Appendix D presents the well summary sheet for Borehole C4545. Appendix E contains the borehole log for Borehole C4545. Appendix F contains the geophysical log for Borehole C4545.

1.2 BACKGROUND

The 200-PW-3 OU waste sites, which are located in the 200 East and 200 West Areas, received organic-rich wastes containing hexone, normal paraffin hydrocarbons (NPH), and tributyl phosphate from separations facilities such as S Plant (reduction-oxidation or REDOX process), A Plant (plutonium-uranium extraction or PUREX process), U Plant (uranium recovery process), and the 201-C Building (hot semiworks process). These organic compounds were used in solvent-extraction processes, and the potential may exist for increased mobilization of radionuclides in the soil column beneath liquid-discharge sites. Most organic solvents are expected to have vaporized or biodegraded after entering the environment, but some primary contaminants or degradation products may persist. A minimum organic inventory of 2,900 kg qualified a site for inclusion in this OU (DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*).

1.2.1 216-A-8 Crib

The 216-A-8 Crib is located approximately 200 m (650 ft) east of the A/AX/AY/AZ Tank Farms complex in the 200 East Area. The bottom dimensions of the crib are 259 x 6 m (850 x 20 ft). A 60 cm (24-in.) diameter, schedule 20, perforated distribution line extends the length of the crib and rests on a 2 m (6.5-ft) thick layer of rock capped by a 30 cm (12-in.) thick layer of gravel. The gravel fill is mounded over the distribution line. Two layers of fabric paper cover the gravel and prevent filling of void space by the overlying native sand backfill. The depth of the excavation varied from 4.9 to 5.8 m (16 to 19 ft) below ground surface as established in 1955. The 216-A-8 Crib was surface stabilized in September 1990 by the addition of 0.6 m (2 ft) of clean fill (DOE/RL-92-04, *PUREX Plant Source Aggregate Area Management Study Report*).

The distribution line contains two 41 cm (16-in.) diameter gooseneck structures, one at each end of the crib, to improve water flow into the crib gravel. These structures provided overflow capacity into the head-end of the crib as well as to a surface pond at the far end of the crib. Four regularly spaced, perforated test risers with filter housings were set into the crib rock layer, offset 1.5 m (5 ft) from the distribution line. Wastewater entered the crib though the 216-A-508 Control Structure (diversion box) located west of the crib. The crib was permanently isolated in April 1995 by filling the 216-A-508 Control Structure with concrete.

The 216-A-8 Crib received vapor condensate from operation of several ventilation systems associated with the A, AX, AY, and AZ Tank Farms. Approximately 87 percent of the liquid waste by volume came from the contact condenser system, which discharged to the 216-A-8 Crib from November 1955 through April 1958. The A Tank Farm first received self-boiling PUREX waste in early 1956. Most of the remaining waste volume came from a surface condenser system installed in 1960 that discharged to the 216-A-8 Crib between 1966 and 1976. Addition of the AY and AZ Tank Farms to the then-active A and AX Tank Farms also took place during this period. The site received additional waste discharge for a brief period in 1978 and again between 1983 and 1985.

The 216-A-8 Crib received approximately 1.18 billion liters of wastewater between 1955 and 1985. Based on 30 years of operations and proportional flow process sampling, the crib is reported to have received 368 kg of uranium, 50 g of plutonium, and 10,900 Ci of beta emitters (RPP-7494, *Historical Vadose Zone Contamination from A, AX, and C Tank Farm Operations*). An estimate of the radionuclide inventory carried out in 1993 (decayed through December 31, 1989) indicated 51.5 Ci of Sr-90, 522 Ci of Cs-137, 0.0000469 Ci of Ru-106, 0.123 Ci (368 kg) of total uranium, and 50 g of total plutonium (DOE/RL-92-04). An estimate of the hazardous chemical inventory for the 216-A-8 Crib includes approximately 320,000 kg of ammonium carbonate, 24,000 kg of dibutyl phosphate, and 8,400 kg of NPH (DOE/RL-2001-01).

1.2.2 Borehole Site Location Process

The sampling and analysis plan for the 216-A-8 Crib included sampling to be conducted before the characterization borehole was drilled to determine the best location for the borehole (DOE/RL-2001-01, Appendix B). Four types of sampling were proposed:

- Geophysical logging of up to five existing boreholes along the length of the crib for gamma-emitting radionuclides. The five boreholes are anticipated to be 299-E25-4, 299-E25-5, 299-E25-7, 299-E25-8, and 299-E25-9. The list of proposed boreholes may need to be modified, depending on well construction and access

- In situ soil-vapor sampling from the same five existing boreholes. The samples would be collected from the screened zone, which would be isolated by use of a downhole packer. The samples would be analyzed for volatile/semivolatile organic compounds using a field-screening organic-vapor-detection device

- In situ soil-vapor sampling from vent risers installed along the length of the crib. The samples would be analyzed for volatile/semivolatile organic compounds using a field-screening organic-vapor-detection device. The feasibility of this task will be evaluated based on the condition and accessibility of the vent risers

- In situ soil-vapor sampling at up to five locations along the length of the crib. A direct-push technology would be used for subsurface access. It is anticipated that the direct-push technology would not be able to extend beyond approximately 2.4 m (8 ft) below ground surface (bgs), which corresponds to the top of the rock layer used to construct the crib. However, it is anticipated that organics present at the base of the crib could be detected within the crib. The samples would be analyzed for volatile/semivolatile organic compounds using a field-screening organic-vapor-detection device.

According to the sampling and analysis plan, the borehole was to be drilled at the location with the highest organic concentrations. If no organics were detected or if the results were inconclusive, the borehole was to be drilled at the location with the highest radionuclide concentrations.

Three of the proposed types of sampling were conducted to guide selection of the location for Borehole C4545. In situ soil-vapor sampling was conducted at five locations along the length of the crib using a GeoProbe for subsurface access, as described in Section 1.2.2.1. In situ soil-vapor samples were collected from five existing wells in the 216-A-8 Crib, as described in Section 1.2.2.2. Geophysical logging was conducted in six existing wells, as described in Section 1.2.2.3. The results obtained from these activities were used to select the optimal location for drilling Borehole C4545, as described in Section 1.2.2.4.

In situ soil-vapor sampling from vent risers was not conducted because of radiological control concerns. The test risers were determined to be inaccessible because of the presence of radiological contamination within the risers, leading to an unacceptable potential for spreading contamination to vapor-sampling equipment and sampling personnel. In accordance with the sampling and analysis plan (DOE/RL-2001-01, Appendix B), this activity was determined not to be feasible, based on the condition and accessibility of the test risers.

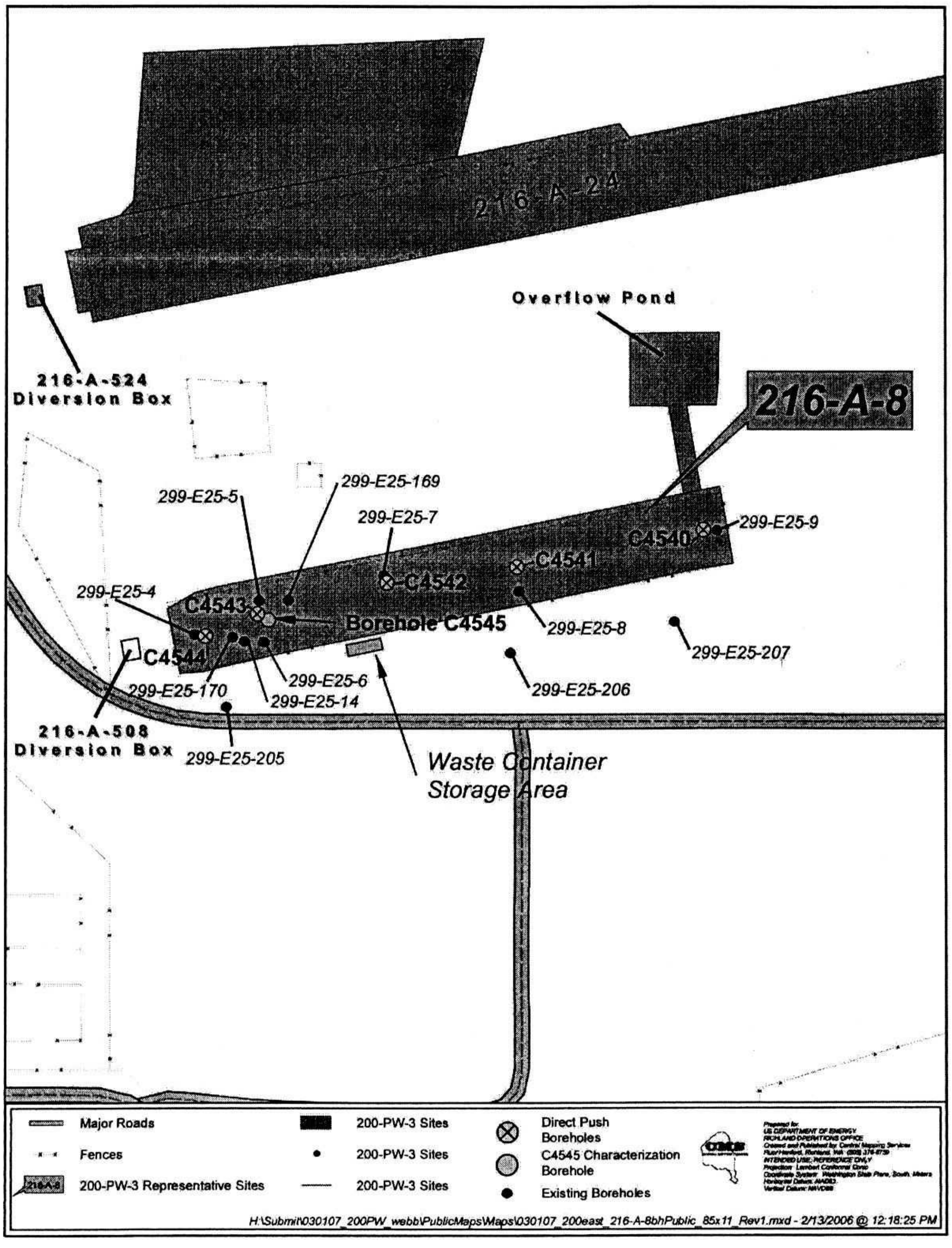
Figure 1-2 shows the 216-A-8 Crib and the locations of the direct-push (GeoProbe) boreholes, existing wells, and characterization Borehole C4545.

1.2.2.1 Soil Vapor Sampling in Direct-Push Boreholes

Soil vapor sampling was conducted in five direct-push boreholes that were installed along the length of the 216-A-8 Crib using the GeoProbe in July 2004. Figure 1-2 shows the location of the five boreholes (C4540, C4541, C4542, C4543, and C4544). Following is a brief summary of this investigation. Appendix A presents the details of this investigation.

Borehole C4540 was advanced to approximately 3.7 m (12 ft) bgs. Boreholes C4541, C4542, C4543, and C4544 each were advanced to approximately 4.6 m (15 ft) bgs. Before the sampling, the casing in each borehole was drawn back to provide a 0.3 m (1-ft) sampling interval of exposed formation at the bottom of the borehole. Decommissioning took place after the sampling was completed.

Figure 1-2. Location of Existing Boreholes, Direct-Push Boreholes, and Characterization Borehole C4545 at the 216-A-8 Crib.



An organic vapor monitor (OVM) was used to provide real-time field-screening results for soil-vapor samples collected from the five GeoProbe push holes. Borehole C4543 had the highest OVM reading (2 ppm). Soil-vapor samples were collected in Tedlar bags for field screening for specific volatile organic compounds using the Photovac 10S Plus Gas Chromatograph and the Innova Multigas Analyzer. Analytical results did not exceed the detection limit for any constituent. Four specific types of Dräger tubes (colorimetric indicator tubes) were selected to cover the range of organic contaminants that might be present, in addition to the volatile organic compounds that could be analyzed using the gas chromatograph and Innova analyzer. These four types of Dräger tubes were used to test for ammonia, a range of easily oxidized compounds, and hydrocarbons. The only soil-vapor samples that showed Dräger tube test reactions were from Boreholes C4544 and C4540, and the reactions were weak trace reactions for hydrocarbons in both cases.

An industrial hygiene technician detected trace amounts of contaminants immediately after back pulling the borehole casing and removing the back-pull tool from the top of the casing at Boreholes C4542 and C4543. These initial concentration levels quickly decayed.

A radiological control technician RCT) detected radiological contamination on the metal mesh sampling probes removed from Boreholes C4542 and C4541, indicating the presence of radiological contamination at the bottom of each of the boreholes. Contamination on the mesh probe from Borehole C4542 initially measured at 6,000 counts/min $\beta\gamma$, with 3,500 counts/min $\beta\gamma$ shown to be removable. Contamination from Borehole C4541 was 40,000 counts/min $\beta\gamma$

Appendix A provides a complete listing of analytical results.

1.2.2.2 Soil-Vapor Sampling in Existing Wells

Additional soil-vapor sampling took place at five existing wells at the 216-A-8 Crib (299-E25-4, 299-E25-5, 299-E25-7, 299-E25-8, and 299-E25-9) during April 2005. Figure 1-2 shows the locations of these five wells. In each well, a soil-vapor sample was pumped from the screened interval, which was isolated by using a downhole packer. The packer was set at depths ranging from 69.5 to 72.8 m (228 to 239 ft). A field-screening instrument (MIRAN SapphIRe Ambient Air Analyzer) was used to analyze the soil-vapor samples for volatile- and semivolatile organic compounds. Following is a brief summary of this investigation. Appendix B provides details of this investigation.

The MIRAN SapphIRe Ambient Air Analyzer has two operational modes. In spectrum-scan mode, the MIRAN SapphIRe Ambient Air Analyzer can be used to identify, in one run, up to five compounds in its library that best match the frequency spectrum of the sample. In single-compound mode, the MIRAN SapphIRe Ambient Air Analyzer can be used to scan for each of the compounds in its library, but for only one compound at a time in each run and without compensation for any potential cross-interference from other compounds. Appendix B lists the compounds in the MIRAN SapphIRe Ambient Air Analyzer library.

Initial operation of the MIRAN SapphIRe Ambient Air Analyzer in spectrum-scan mode allowed scanning of each soil-vapor sample for the possible presence of up to five of the organic compounds in the instrument library. No organic compounds were detected in any of the soil-vapor samples from the five wells. As a result, the instrument was not reconfigured to analyze the samples in single-compound mode.

Before and during all sampling activities, an industrial hygiene technician conducted health and safety monitoring using a photoionization detector. Upon removal of the wellhead cover at each well, the industrial hygiene technician monitored the wellhead using the photoionization detector. Wells 299-E25-4, 299-E25-5, 299-E22-7, and 299-E25-9 showed no detectable vapor concentrations. The industrial hygiene technician initially detected transient values of 1 ppm in Well 299-E25-8, but these readings decayed to zero after less than 3 seconds.

Following vapor-sampling activities at each well, an RCT conducted radiological field screening of all down-hole equipment (e.g., packer, tubing, cables) removed from each well. The RCT found all down-hole equipment to be at background levels for the area for Wells 299-E25-4, 299-E25-5, 299-E25-7, and 299-E25-8. However, during the extraction of the packer from Well 299-E25-9, the RCT found elevated radiological activity above background levels. The elevated levels decayed to background levels after a couple of minutes, and the RCT determined that the elevated readings were from radon.

1.2.2.3 Geophysical Logging in Existing Wells

Geophysical logging was conducted in five existing wells from which soil-vapor samples were collected (299-E25-4, 299-E25-5, 299-E25-7, 299-E25-8, and 299-E25-9), and in one other existing well (299-E25-6), between April 2004 and July 2004. Figure 1-2 shows the locations of these wells. Following is a brief summary of each geophysical log. Appendix C provides the complete geophysical logging report for each well investigated.

Borehole geophysical logging records the depth-distribution of gamma-emitting radionuclides in the soil to locate and quantify intervals of contamination. The geophysical logging system provided a continuous radiometric signature of the soils. Cesium-137 was the only man-made radionuclide detected in each of the six existing boreholes investigated. The highest concentration of Cs-137 was detected in Well 299-E25-5. Table 1-1 lists the maximum Cs-137 concentration detected in each well.

Two intervals in Well 299-E25-4 showed detectable Cs-137. The interval from near the ground surface to 9.1 m (30 ft) below top of casing (TOC) showed concentrations ranging from the minimum detection level (MDL) (0.3 pCi/g) to a maximum of 13.1 pCi/g at 7.9 m (26 ft) below TOC. The interval between 69.2 and 75.3 m (227 and 247 ft) below TOC showed concentrations ranging from near the MDL to1.4 pCi/g.

Three intervals in Well 299-E25-5 showed detectable Cs-137. The interval from near the ground surface to 1.8 (6 ft) below TOC showed concentrations ranging from the MDL to 12.8 pCi/g. The interval between 6.1 and 16.2 m (20 and 53 ft) below TOC showed concentrations ranging from 0.4 pCi/g to a maximum of 30,800 pCi/g measured at 7.6 m (25 ft) below TOC. The interval between 70.7 and 78.9 m (232 and 259 ft) below TOC showed concentrations ranging from near the MDL to a maximum of 0.8 pCi/g measured at 70.7 m (232 ft) below TOC.

Table 1-1. Maximum Cesium-137 Concentrations from Geophysical Logging of Existing Wells at the 216-A-8 Crib.

Well	Maximum Cs-137 Concentration (pCi/g)	Depth of Maximum Cs-137 Concentration (ft below Top of Casing)
299-E25-4	13.1	26
299-E25-5	30,800	25
299-E25-6	50	25-30
299-E25-7	5.7	9
299-E25-8	4.5	5
299-E25-9	13	5

Three intervals in Well 299-E25-6 showed detectable Cs-137. The interval between 2.7 and 3.6 m (9 and 11 ft) below TOC showed a maximum concentration of 9.8 pCi/g. The interval between 6.7 and 22.3 m (22 and 73 ft) below TOC showed concentrations ranging from the MDL to a maximum of 50 pCi/g measured between 7.6 and 9.1 m (25 and 30 ft) below TOC. The interval between 69.2 and 71.3 m (227 and 234 ft) below TOC showed a maximum concentration of 3.2 pCi/g.

Three intervals in Well 299-E25-7 showed detectable Cs-137. The interval from near the ground surface to 2.7 m (9 ft) below TOC showed a range of concentrations from the MDL to 5.7 pCi/g. The interval from 6.1 to 18.0 m (20 to 59 ft) below TOC showed concentrations ranging from 0.3 pCi/g to a maximum of 3.6 pCi/g measured at 7.6 m (25 ft) below TOC. The interval between 68.6 and 71.9 m (225 and 236 ft) bgs showed concentrations ranging from near the MDL to a maximum of 3.2 pCi/g measured at 69.5 m (228 ft) below TOC.

One interval in Well 299-E25-8 showed detectable Cs-137. The interval between 71.3 and 73.1 m (234 and 240 ft) below TOC showed a range of concentrations from near the MDL to a maximum of 2.5 pCi/g measured at 72.2 m (237 ft) below TOC. Concentrations of Cs-137 were present at 1.5 m (5 ft) below TOC, at approximately 6.7 m (22 ft) below TOC, and at a few other sporadic locations throughout the well. The overall range of concentrations for this well was from the MDL to a maximum of 4.5 pCi/g at 1.5 m (5 ft) below TOC.

Two intervals in Well 299-E25-9 showed detectable Cs-137, including the interval between 68.9 and 72.8 m (226 and 239 ft) below TOC and the interval between 75.0 and 76.2 m (246 and 250 ft) below TOC. Cesium-137 occurs near the ground surface and at a few sporadic locations throughout the borehole. The overall range of concentrations for this well was from the MDL to a maximum of 13 pCi/g at 1.5 m (5 ft) below TOC. The Cs-137 detected between 68.9 and 70.7 m (226 and 232 ft) below TOC is located at a depth interval consistent with the depth of a packer set at 69.5 m (228 ft) bgs. Cs-137 detected at 72.8 m (239 ft) below TOC is approximately 6.1 m (20 ft) above the groundwater level.

1.2.2.4 Location of Borehole C4545

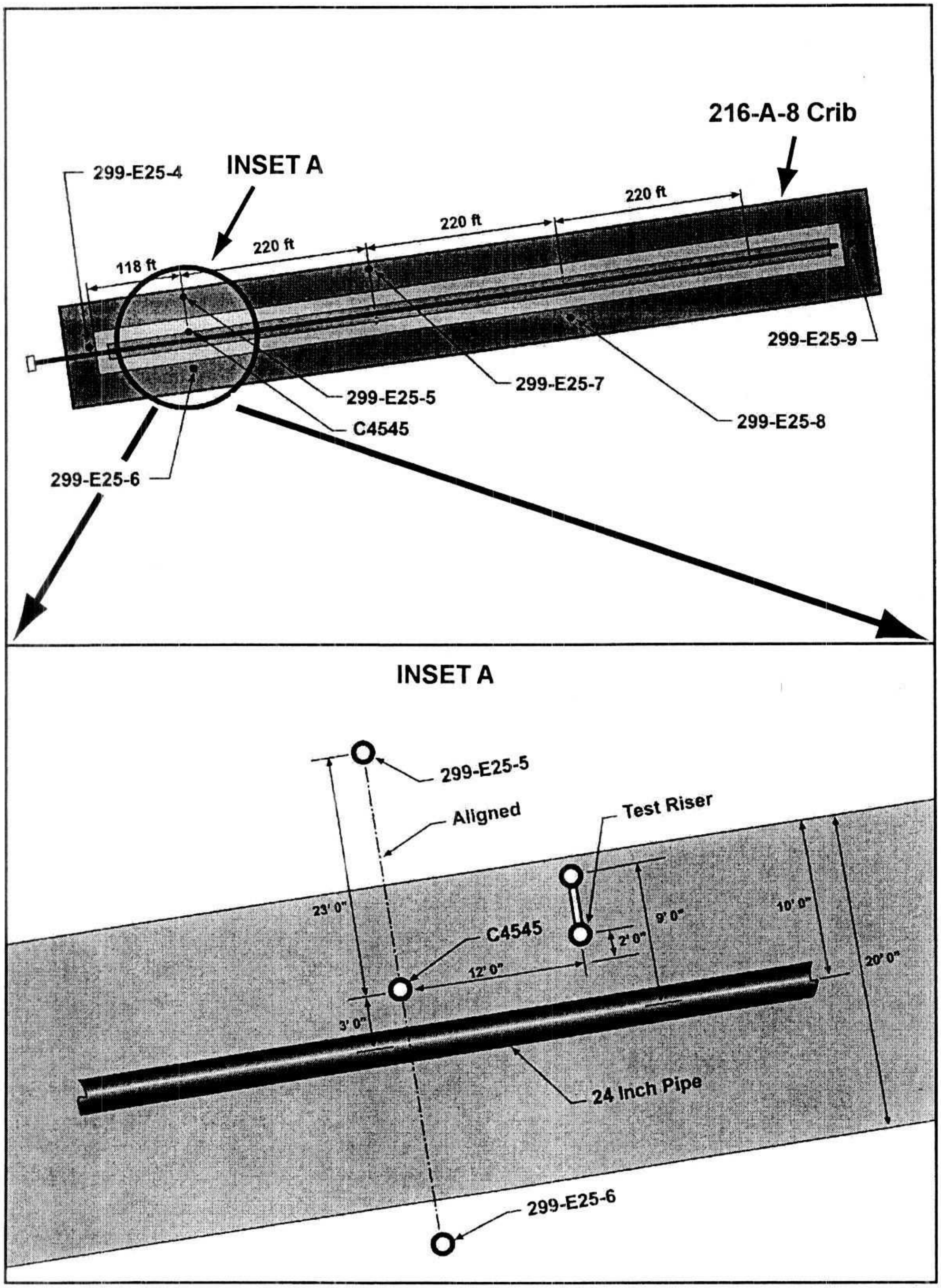
The sampling and analysis plan (DOE/RL-2001-01, Appendix B) provided guidance for selection of the final location of Borehole C4545. This guidance states the following.

- The borehole will be drilled at the location of the highest organic concentrations.
- If no organics are detected or if the results are inconclusive, the borehole will be drilled at the location with the highest radionuclide concentrations.

The results of the soil-vapor sampling investigations in the shallow and deep vadose zone, as summarized in Sections 1.2.2.1 and 1.2.2.2, respectively, did not indicate conclusively the presence of organics at any of the locations sampled. However, the geophysical logging investigation, as summarized in Section 1.2.2.3, clearly identified the location with the highest radiological concentrations. Existing Well 299-E25-5 exhibited the highest radiological concentrations, with a maximum Cs-137 value of 30,800 pCi/g found at 7.6 m (25 ft) below TOC. The second highest levels occur in existing Well 299-E25-6, with a Cs-137 concentration of 50 pCi/g in the interval from 7.6 to 9.1 m (25 to 30 ft) below TOC. The area that demonstrated the highest radiological concentrations is located near the west end of the 216-A-8 Crib, as anticipated in DOE/RL-2001-01, Appendix B.

Therefore, based on the guidance set forth in DOE/RL-2001-01, Appendix B, and on the results of these three investigations at the 216-A-8 Crib, Borehole C4545 was located near Well 299-E25-5. The borehole was located on the south side of Well 299-E25-5, so that it would be closer to the center of the 216-A-8 Crib and closer to Well 299-E25-6, where contamination appeared to be slightly deeper, for groundwater protection. This location, shown on Figure 1-3, lies 7.0 m (23 ft) from Well 299-E25-5 and 0.9 m (3 ft) from the center of the 216-A-8 Crib discharge pipe.

Figure 1-3. Planned Location for Borehole C4545 at the 216-A-8 Crib.



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2.0 FIELD ACTIVITIES

The primary purpose of field activities was to characterize the nature and extent of contamination underlying the 216-A-8 Crib in the 200-PW-3 OU in the 200 East Area. The information gained from the drilling, sampling, and geophysical logging of Borehole C4545 will support the remedial investigation report for this OU and will support verification of, and potential modifications to, the existing conceptual model.

Field activities included pushing five GeoProbe boreholes to depths of 3.7 to 4.6 m (12 to 15 ft) bgs, collecting and analyzing soil-vapor samples from these boreholes, collecting and analyzing soil-vapor samples from five existing wells, and geophysically logging six existing wells. This information was used to locate Borehole C4545. Section 1.2.2 provides a more detailed description of these activities.

Following location of the drilling site, Borehole C4545 was drilled to groundwater. Additional activities included the collection of soil-characterization samples from sediments encountered while drilling and the geophysical logging of the borehole. The borehole was backfilled and decommissioned after completion of drilling, sampling, and geophysical logging. Figure 1-2 shows the 216-A-8 Crib and locations of the GeoProbe boreholes, existing wells, and Borehole C4545.

2.1 BOREHOLE CONSTRUCTION AND DECOMMISSIONING

2.1.1 Drilling Methods

Planning, drilling, and decommissioning of Borehole C4545 adhered to the guidelines and requirements presented in GRP-EE-02-14.1 (*Drilling, Remediating, and Decommissioning Resource Protection Wells and Geotechnical Soil Borings*). The borehole conformed to standards defined in WAC-173-160 (*Minimum Standards for Construction and Maintenance of Wells*). Drilling of Borehole C4545 at the 216-A-8 Crib representative waste site began on June 6, 2005, and finished on June 30, 2005. Drilling reached a total depth of 80.6 m (264.5 ft) bgs.

The drilling used a cable-tool drilling rig, and drill cuttings were recovered from a drive-barrel. Two telescoped, threaded carbon-steel temporary casings kept the borehole open and minimized the potential for down-hole cross-contamination. The first temporary casing string, with an outside diameter of 27.5 cm (10.8125 in.) was installed in the interval from 0 to 20.94 m (68.71 ft) bgs. The second temporary casing string, with an OD of 22.1 cm (8.6875 in.) was installed in the interval from 0 to 80.59 m (264.43 ft) bgs. Sediments recovered during the drilling process were surveyed on a routine basis for radioactivity and organic vapors throughout the high- and medium-risk portions of the borehole (i.e., between the surface and 21.3 m [70 ft] bgs). Surveying during the low-risk portion of the drilling (i.e., below 21.3 m [70 ft] bgs) was on a twice-daily basis (i.e., AM/PM checks) for the remainder of the drilling. Drilling personnel did not add water to the borehole during drilling.

After total depth was reached, borehole geophysical logging for gamma-emitting radionuclides was complete.

Table 2-1 shows borehole summary information. Appendix D contains the well summary sheet for Borehole C4545, Appendix E contains the borehole log for Borehole C4545, and Appendix F contains the geophysical log for Borehole C4545.

Table 2-1. 216-A-8 Borehole Construction and Survey Summary.

Well identification number	C4545
Area	200 East Area
Northing [a] (m)	136,176.35
Easting [a] (m)	575,682.46
Ground surface elevation[b] (m)	201.78
Drill start date	June 6, 2005
Drill end date	June 30, 2005
Total depth (m/ft bgs)	80.6 / 264.5
Depth to water (m/ft bgs)	79.75 / 261.67 (June 30, 2005)
Sample intervals (ft bgs)	1.5; 19-21.5; 22.5-25; 25-27.5; 27.5-30; 49-51.5; 104-106.5; 178-180.5; 234-236.5; 262-264.5
Decommissioning data (depth in ft bgs):	
• Sand backfill (10-20 mesh Colorado silica sand)	• 264.0 - 256.9
• Granular bentonite (#8)	• 256.9 – 1.0
• Portland cement surface cap	• 1.0 – 0.0
Decommissioning start – finish dates	07/06/05 - 07/21/05
Comments	Brass tag in surface cap

[a] Northing and easting coordinates are based on Washington State Plane Coordinates NAD83, *North American Datum of 1983*, as revised 1991, rounded to 1 m.
[b] NAVD88, *North American Vertical Datum of 1988* value, rounded to 0.001 m.
bgs = below ground surface.

2.1.2 Well Decommissioning

Decommissioning of Borehole C4545 occurred in July 2005. Decommissioning included removing all temporary casing and backfilling the borehole. Borehole fill below the water table consists of 10-20 mesh Colorado silica sand emplaced during casing extraction to maintain natural groundwater flow. Bentonite (#8 bentonite crumbles) filled the remaining void while the casing was removed, forming a seal from the top of the sand pack to just below the ground surface. Periodic measurement of sand and/or bentonite levels within the casing ensured continuous overlap, preventing formation sediments from collapsing into the borehole.
A surface seal of Portland cement, together with a brass survey tag embedded in the cement, completed borehole decommissioning. Embossment on the brass tag included the well identification number and decommissioning date, in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells."

Table 2-1 contains borehole survey and grout seal interval information.

2.2 BOREHOLE SOIL SAMPLING

Collection of soil samples at specific depths was in accordance with the sample design in the sampling and analysis plan (DOE/RL-2001-01, Appendix B). The depths of the proposed samples below ground surface were modified to account for the 0.3 m (1-ft) thick crushed rock fill added to form the drill pad. Lithologic variations and changes in chemical or radiological contamination also resulted in the modification of some of the sampling intervals during drilling. Table 2-1 lists the sample intervals for Borehole C4545. In situ soil samples were collected for chemical and radiological analysis using a split-spoon drive-barrel sampler with four stainless steel liners, each 15.2 cm (6 in.) long. The split-spoon samplers were opened on an enclosed sample table equipped with a high-efficiency particulate air (filter) vacuum system. Core barrels and samples were sleeved with plastic sleeving during drilling in the high-risk zone. The samples were submitted to analytical laboratories for chemical and radiological analysis and determination of physical properties. Collection and transportation of soil samples was in accordance with internal Fluor Hanford procedures GRP-EE-01-4.0, *Soil and Sediment Sampling*, and GRP-EE-01-3.1, *Sample Packaging and Shipping*.

The primary focus of sampling beneath the 216-A-8 Crib was to characterize the vadose zone for the nature and distribution of organic and radiological contaminants. Based on the sampling design in the sampling and analysis plan, seven samples were to be collected, including one from each major geologic unit, during drilling of the borehole (DOE/RL-2001-01, Appendix B). The rationale for each sample depth (as presented in the plan) is as follows:

- 5.5 to 6.2 m (18 to 20.5 ft) bgs -- Characterize the vadose zone immediately below the base of the crib; organic layer observed immediately below the 216-A-24 Crib

- 6.6 to 7.3 m (21.5 to 24 ft) bgs -- Characterize the zone of highest cesium contamination detected during spectral gamma geophysical logging

- 15.2 to 16.0 m (50 to 52.5 ft) bgs -- Characterize the zone just below the cesium contamination detected during spectral gamma geophysical logging

- 31.2 to 32.0 m (102.5 to 105 ft) bgs -- Characterize the zone at the maximum depth of contamination indicated by gross gamma geophysical logging

- 54.1 to 54.9 m (177.5 to 180 ft) bgs -- Characterize the contaminant distribution at the contact between the Hanford formation sand-dominated and lower gravel-dominated sequences

- 71.0 to 71.8 m (233 to 235.5 ft) bgs -- Characterize the deep zone of cesium contamination detected during spectral gamma geophysical logging

- 79.7 to 80.5 m (261.5 to 264 ft) bgs -- Characterize the capillary fringe to evaluate impact to groundwater.

An additional sample was required from the near-surface (0.2 m [0.5 ft] bgs) to support management and designation of the waste. Two unplanned samples were collected from the interval 7.6 to 8.4 m (25 to 27.5 ft) bgs and the interval 8.4 to 9.1 m (27.5 to 30 ft) bgs. A sample was collected in the interval 7.6 to 8.4 m (25 to 27.5 ft) bgs after a decrease in radiological readings was noted. However, the exhauster on the sample table enclosure failed while the subsamples were being collected from the split-spoon sampler from this interval, and the subsequent interval (8.4 to 9.1 m [27.5 to 30 ft] bgs) was sampled to provide a complete sample suite at this depth. Sample intervals are shown on Figure 2-1.

Samples collected to meet the 200-PW-3 OU representative waste site sampling objectives are summarized in Table 2-2. The remedial investigation report will contain the chemical and radiological analytical results from this drilling. (Note: The soil sample intervals are 0.8 m [2.5 ft] long, which includes the 0.6 m [2-ft] long split-spoon sampler and the 0.2 m [0.5-ft] long shoe at the base of the sampler. The soil sample intervals on the geologist's borehole log (Appendix E) are 0.6 m (2 ft) long, based on the length of the split-spoon sampler without the shoe.)

Table 2-2. Sample Collection Information Summary. (2 Pages)

HEIS Number	Sample Collection Date	Sample Interval*		Comment
		Top (ft bgs)	Bottom (ft bgs)	
Soil Samples				
B1D7C5	June 2, 2005	1.5	1.5	Soil (grab) sample (pesticides, herbicides)
B1D9C0	June 8, 2005	19	21.5	Soil sample (radionuclides)
B1D9Y4	June 8, 2005	19	21.5	Soil sample
B1D9C1	June 8, 2005	22.5	25	Soil sample (radionuclides)
B1D9Y5	June 8, 2005	22.5	25	Soil sample
B1D9Y3	June 9, 2005	25	27.5	Activity scan
B1DB28	June 9, 2005	25	27.5	Activity scan
B1DB25	June 9, 2005	25	27.5	Primary replicate soil sample (volatile organic analysis)
B1DB24	June 9, 2005	25	27.5	Replicate soil sample (volatile organic analysis)
B1D7C6	June 13, 2005	27.5	30	Activity scan
B1D7C8	June 13, 2005	27.5	30	Primary split soil sample
B1D7C7	June 13, 2005	27.5	30	Split soil sample
B1D7D1	June 14, 2005	49	51.5	Activity scan
B1D7C9	June 14, 2005	49	51.5	Primary replicate soil sample
B1D7D0	June 14, 2005	49	51.5	Replicate soil sample
B1D987	June 23, 2005	104	106.5	Activity scan
B1D992	June 23, 2005	104	106.5	Soil sample
B1D988	June 27, 2005	178	180.5	Activity scan

Table 2-2. Sample Collection Information Summary. (2 Pages)

HEIS Number	Sample Collection Date	Sample Interval*		Comment
		Top (ft bgs)	Bottom (ft bgs)	
B1D993	June 27, 2005	178	180.5	Soil sample
B1D989	June 29, 2005	234	236.5	Activity scan
B1D994	June 29, 2005	234	236.5	Soil sample
B1D990	June 30, 2005	262	264.5	Activity scan
B1D995	June 30, 2005	262	264.5	Soil sample
Equipment Blanks				
B1D7F1	June 7, 2005	N/A	N/A	
B1D7F2	June 7, 2005	N/A	N/A	
Trip Blanks				
B1D7D3	June 7, 2005	N/A	N/A	Volatile organic analysis
B1D7D4	June 13, 2005	N/A	N/A	Volatile organic analysis
B1D7D5	June 14, 2005	N/A	N/A	Volatile organic analysis
B1D7D7	June 23, 2005	N/A	N/A	Volatile organic analysis
B1D7D8	June 27, 2005	N/A	N/A	Volatile organic analysis
B1D7D9	June 29, 2005	N/A	N/A	Volatile organic analysis
B1D7F0	June 30, 2005	N/A	N/A	Volatile organic analysis

* Sample depths were adjusted by 0.3 m (1 ft) from originally planned depths to account for added drill pad material.

bgs = below ground surface.
N/A = not applicable.
HEIS = *Hanford Environmental Information System* database.

2.3 FIELD SCREENING

Field radiation screening consisted of two types of activities; surface radiation surveys performed before drilling activities as well as following drilling activities, and field screening of cuttings and soil samples brought to the surface during the drilling process.

The surface radiation survey performed at the waste site before drilling activities documents any existing surface contamination and supports preparation of health and safety documentation. Qualified RCTs carried out surface radiation surveys in accordance with applicable health and safety procedures and prepared a survey report for the site. A post-drilling survey at the drill site ensured that sampling activities did not contribute to surface contamination. HNF-IP-1277, *Deactivation & Decommissioning Radiation Protection Procedures*, Section 5.6.15, "Operation of Mobile Surface Contamination Monitor II," or other applicable approved procedures controlled these surveys.

All samples and cuttings from the borehole were field screened by the RCTs for evidence of radioactive contamination. Field screening helped to identify the bottom of the waste site, aided in adjusting sample intervals as necessary, and assisted in determining sample shipment requirements, in addition to supporting worker health and safety monitoring. RCTs screened soil samples for alpha, beta, and gamma radioactivity before the samples were placed into containers and shipped from the drill site. The RCTs recorded all field measurements, noting the depth of the sample and the instrument reading.

Classification of the drilling as high to medium risk or low risk reflects sampling and geophysical logging information from nearby wells. This classification resulted in continuous radiological field screening of the drill cuttings and immediate work area by the RCTs during drilling activities in high- to medium-risk intervals (i.e., between the surface and 21.3 m [70 ft] bgs). RCT coverage in low-risk intervals (i.e., deeper than 21.3 m [70 ft] bgs) was on an AM/PM basis. A Radiological Work Permit was prepared to cover working with radioactive contaminated soils.

Radiological monitoring of drilling spoils from the interval 4.0 to 4.6 m (13 to 15 ft) bgs on June 7, 2005, showed elevated beta-gamma readings, indicating the presence of radioactive material in the soils. These elevated readings resulted in conversion of the work zone to a radiological contamination area. The radiological contamination area was subsequently downposted at a depth of 21.3 m (70 ft) bgs on June 21, 2005. Table 2-3 summarizes all direct radiation measurements recorded from Borehole C4545. Figure 2-1 presents direct contamination measurements correlated to the borehole geology at Borehole C4545. Figure 2-1 also includes direct-dose-rate measurements recorded for Borehole C4545, as well as information from geophysical logging of the borehole.

2.4 AIR MONITORING

The industrial hygiene technician provided air monitoring on a full-time basis while the borehole was drilled through the high- to medium-risk interval (i.e., between surface and 21.3 m [70 ft] bgs) and then on a twice-daily basis during drilling in low-risk intervals (i.e., deeper than 21.3 m [70 ft] bgs). Drill cuttings and soil samples were screened for volatile organics using hand-held organic vapor analyzers. Table 2-4 summarizes these monitoring results.

The industrial hygiene technician reported a reading of ~6 ppm organic vapors, measured with an OVM, from cuttings found between 14.2 and 14.6 m (46.5 and 48 ft) bgs, just beneath the semiconfining silty-sand layer encountered between 14.0 and 14.6 m (46 and 46.5 ft) bgs. This was a transient, nonreproducible reading. The industrial hygiene technician also reported sustained elevated OVM readings, with a maximum reading of ~2 ppm/M, from cuttings found between 16.5 and 16.8 m (54 and 55 ft) bgs.

Table 2-3. Radiation Control Measurements from Borehole C4545 Sediments. (2 Pages)

Dare Surveyed	Borehole Depth (ft)	Direct Measurements			Direct-Dose-Rate Measurements (Contact) RO-3B (CP)[d]		Background Measurements			Media/ Source
		PG-2[a] βγ counts/ min	SPA-3[b] βγ counts/ min	GM[c] α counts/ min	Shallow (mrem/h)	Deep (mrem/h)	PG-2[a] βγ counts/ min	SPA-3[b] βγ counts/ min	PAM[c] α counts/ min	
06/06/05	0-10	-	2.3 K	-	-	-	-	2 K	-	soil/drill cuttings
06/07/05	10	1.3 K	2.2 K	-	-	-	1.3 K	2.2 K	-	soil/drill cuttings
	14	3.5 K	6.9 K	-	-	-	1.3 K	2.2 K	-	soil/drill cuttings
06/08/05	19	-	-	-	< 0.5	< 0.5	-	-	-	soil/drill cuttings
	21	-	-	-	180	180	-	-	-	soil/drill cuttings
	22	-	-	-	50	50	-	-	-	split-spoon sample
	22	-	-	-	140	140	-	-	-	soil/drill cuttings
	23	-	-	-	50	50	-	-	-	soil/drill cuttings
	23	-	-	-	120	120	-	-	-	soil/drill cuttings
	23-25	-	-	-	50	50	-	-	-	split-spoon sample
06/09/05	25-27	-	-	-	8	8	-	-	-	split-spoon sample
	25-27	-	-	-	12	12	-	-	-	soil/drill cuttings
06/13/05	26	-	-	-	3	3	-	-	-	soil/drill cuttings
	27-29	-	-	-	<0.5	<0.5	-	-	-	split-spoon sample
	27-29	-	-	3 K	-	-	-	-	100	soil/drill cuttings
	30-37	-	-	-	<0.5	<0.5	-	-	-	soil/drill cuttings
	38	-	-	100	-	-	-	-	100	soil/drill cuttings
06/14/05	38-54	-	-	-	-	<0.5	-	-	-	soil/drill cuttings
	49-51	-	-	-	-	<0.5	-	-	-	split-spoon sample
	54	-	13 K	-	-	-	-	3 K	-	soil/drill cuttings

Table 2-3. Radiation Control Measurements from Borehole C4545 Sediments. (2 Pages)

Dare Surveyed	Borehole Depth (ft)	Direct Measurements			Direct-Dose-Rate Measurements (Contact) RO-3B (CP)[d]		Background Measurements			Media/ Source
		PG-2[a] βγ counts/ min	SPA-3[b] βγ counts/ min	GM[c] α counts/ min	Shallow (mrem/h)	Deep (mrem/h)	PG-2[a] βγ counts/ min	SPA-3[b] βγ counts/ min	PAM[c] α counts/ min	
06/21/05	54-60	-	10 k	-	-	-	-	4 K	-	soil/drill cuttings
	60-64	-	3 K	-	-	-	-	2.8 K	-	soil/drill cuttings
	65-70	-	3 K	-	-	-	-	2.8 K	-	soil/drill cuttings
06/23/05	90	-	2.8 K	-	-	-	-	2.6 K	-	soil/drill cuttings
	105	-	2.6 K	-	-	-	-	2.4 K	-	soil/drill cuttings
06/24/05	153	-	3.16 K	-	-	-	-	3.7 K	-	soil/drill cuttings
06/27/05	181	-	2.9 K	-	-	-	-	2.9 K	-	soil/drill cuttings
06/28/05	225	-	2.9 K	-	-	-	-	2.9 K	-	soil/drill cuttings
06/29/05	235	-	2.9 K	-	-	-	-	2.9 K	-	soil/drill cuttings
	260	-	2.9 K	-	-	-	-	2.9 K	-	soil/drill cuttings
06/30/05	264	-	2.9 K	-	-	-	-	2.9 K	-	soil/drill cuttings

[a] Thermo Electron PG-2 low-energy gamma hand probe.
[b] Thermo Electron high-sensitivity gamma detector.
[c] Geiger-Mueller meter.
[d] Eberline RO-3B (CP) portable air-filled ionization chamber dose rate meter "Cutie Pie."

α = alpha radiation.
β = beta radiation.
γ = gamma radiation.
K = thousand (x 1,000).

GM = Geiger-Mueller (radiation counter).
PG = PG-2 is a trademark of Thermo Electron Corporation, Santa Fe, New Mexico.
PAM = portable alpha meter.
SPA = SPA-3 is a trademark of Eberline Instruments, a subsidiary of Thermo Electron Corporation, Waltham Massachusetts.

Figure 2-1. Borehole Geology, Direct Radioactive Contamination Measurements, and Geophysical Logging at Borehole C4545.

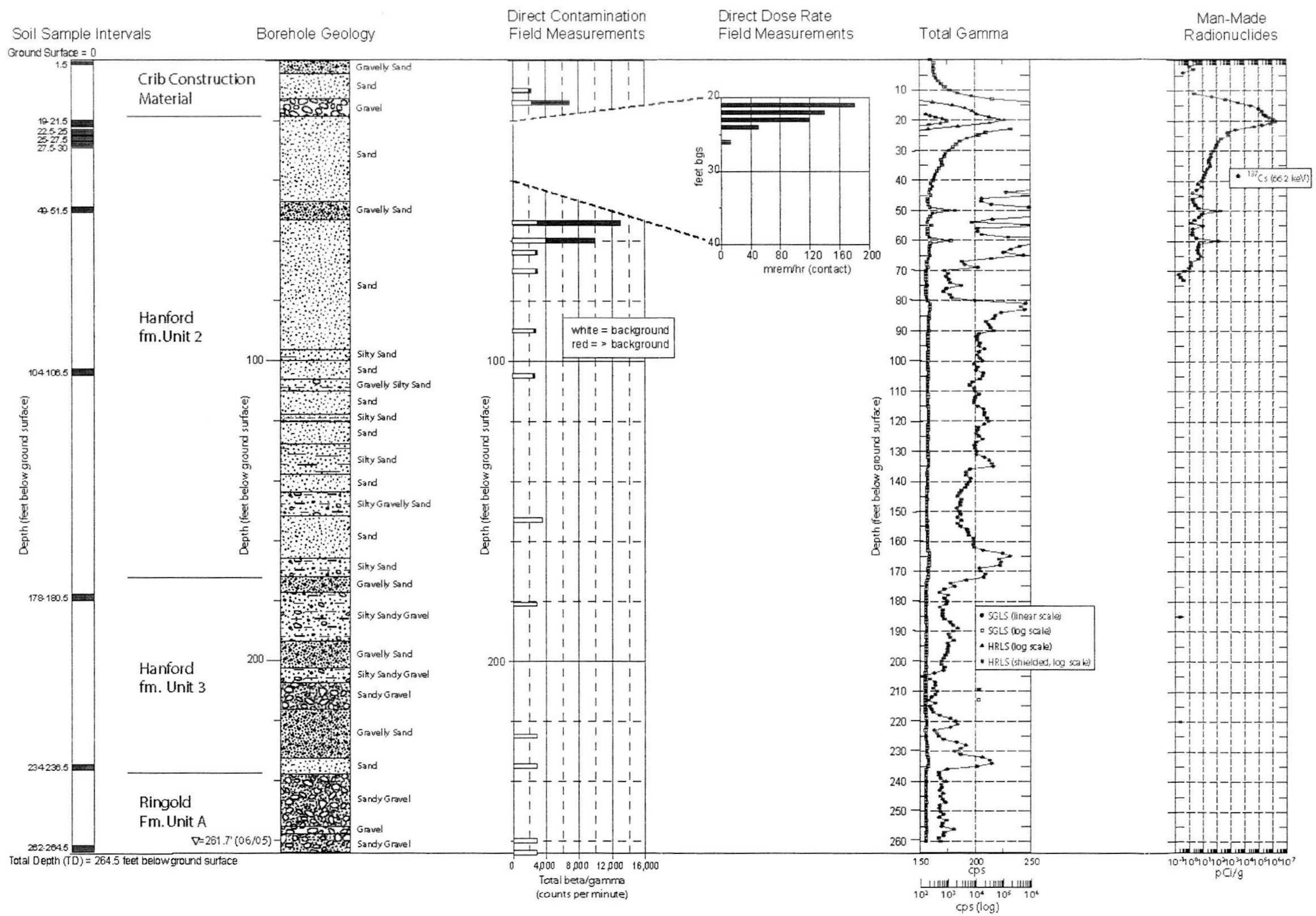


Table 2-4. Industrial Hygiene Monitoring from Borehole C4545 Sediments.

Point Source and Area Field Data										Personal Sampling Data				
			Source		Area									
Date	BH Depth Start (ft)	BH Depth End (ft)	Total Minutes	Max OVM[a] Reading (ppm)	Start Time	Stop Time	Total Minutes	Max OVM[a] Reading (ppm)	Estimated 8-Hour TWA (ppm)	Personal Sample ID	Chloroform TWA (ppm)	Acetone	Methylene Chloride	Tetrachloro-ethylene
06/02/05	1.0[b]	1.5	-	-	-	-	-	-	-	-	-	-	-	-
06/06/05	1.5	10.0	-	-	-	-	-	-	-	-	-	-	-	-
06/07/05	10.0	18.0	3	0.10	0730	0753	-	-	-	-	-	-	-	-
			1	0.02	1407	1408	-	-		-	-	-	-	-
06/08/05	16.5[c]	23.0	-	-	-	-	-	-	-	-	-	-	-	-
06/09/05	23.0	25.0	-	-	-	-	-	-	-	-	-	-	-	-
06/10/05	25.0	25.0	-	-	-	-	-	-	-	-	-	-	-	-
06/13/05	25	38	0.3	1.90	-	-	-	-	-	-	-	-	-	-
06/14/05	38	54	7	5.70	0948	0955	7.0	3.0	0.0506	AK8173	<0.11	-	<0.13	-
			3	4.00	0956	0958	3.0	1.1		AK8055	<0.11	-	<0.13	-
			-	-	-	-	-	-		AK8088	<0.10	-	<0.12	-
06/15/05	54	55	8	1.00	0910	0918	8	1.00	0.0602	-	-	-	-	-
			3	0.90	0912	0915	3	0.90		-	-	-	-	-
			-	-	0924	0926	2.00	1.30		-	-	-	-	-
			3	2.00	0927	0930	-	-		-	-	-	-	-
			13	1.20	1440	1453	13	1.20		-	-	-	-	-
			1	1.90	1510	1511	-	-		-	-	-	-	-
			8	2.90	1512	1520	-	-		-	-	-	-	-
06/16/05	55	55	-	-	-	-	-	-	-	-	-	-	-	-
06/20/05	55	57.5	-	-	-	-	-	-	-	Y46050	<0.00089	<0.0027	<.0018	<00089
			-	-	-	-	-	-		Y47944	<0.00083	0.002	<0.0016	<0.00083
06/21/05	57.5	70	4	0.30	0717	0721	-	-	-	X33274	<D	0.0099	<D	<D
			4	0.50	0721	0725	-	-		X33061	<D	<0.0025	<D	<D
			3	0.20	0728	0731	-	-		-	-	-	-	-
			4	0.20	0731	0734	-	-		-	-	-	-	-
			6	1.70	1030	1036	-	-		-	-	-	-	-
06/22/05	70	70	-	-	-	-	-	-	-	-	-	-	-	-
06/23/05	70	113	-	-	-	-	-	-	-	-	-	-	-	-
06/24/05	113	155	-	-	-	-	-	-	-	-	-	-	-	-
06/27/05	155	189	-	-	-	-	-	-	-	-	-	-	-	-
06/28/05	189	226	-	-	-	-	-	-	-	-	-	-	-	-
06/29/05	226	260	-	-	-	-	-	-	-	-	-	-	-	-
06/30/05	260	264.5	-	-	-	-	-	-	-	-	-	-	-	-

[a] OVM = organic vapor meter with 11.8 eV lamp.
[b] Hand dug below drill pad for surface sample.
[c] Start depth was ~ 16.5 ft below ground surface (slough in casing).

BH = borehole.
ID = identification.
TWA = time-weighted average.

2.5 BOREHOLE GEOPHYSICAL LOGGING

Borehole geophysical logging of Borehole C4545 took place when the borehole was at a depth of 21.3 m (70 ft) bgs and again at total depth for the borehole (80.6 m [264.5 ft] bgs). Borehole geophysical logging records the vertical distribution of radionuclides in the soil beneath the waste site as a means of locating and quantifying contamination, in addition to aiding in interpretation of subsurface stratigraphy. Borehole logging equipment is calibrated annually, with calibration data used to calculate casing attenuation factors that convert measured peak-area count rates to radionuclide concentrations. The logging system provided a continuous radiometric signature of the soils, measured through a single thickness of casing, to a depth approximately 0.3 m (1 ft) above the water table (water table was measured at 79.76 m [261.67 ft] bgs on June 30, 2005). Appendix F contains the geophysical logging results for Borehole C4545. This report provides a brief summary of these results.

Two intervals in Borehole C4545 showed detectable Cs-137; one interval from the ground surface to 1.5 m (5 ft) bgs and the other from 3.4 to 22.3 m (11 to 73 ft) bgs. The highest concentration zone lies between 3.4 and 7.6 m (11 and 25 ft) bgs, with a maximum concentration of approximately 1.5 million pCi/g measured at 6.1 m (20 ft) bgs. Potential casing contamination may be the cause of Cs-137 contamination observed at relatively low concentrations (e.g., below 10 pCi/g) between 12.2 and 22.3 m (40 and 73 ft) bgs and the cause of Cs-137 spikes at probable casing joints at 15.2 and 18.3 m (50 and 60 ft) bgs.

2.6 BOREHOLE CIVIL SURVEY

The boreholes were surveyed in accordance with GRP-EE-01-1.6, *Survey Requirements and Techniques*. Vertical survey data were recorded using NAVD88, *North American Vertical Datum of 1988*, and the horizontal coordinates were recorded using the Washington State Plane (South Zone) NAD83, *North American Datum of 1983*, with the 1991 adjustment for horizontal coordinates. Table 2-1 shows survey data for Borehole C4545.

2.7 WASTE MANAGEMENT

Table 2-5 summarizes the investigation-derived waste from Borehole C4545.

Table 2-5. Summary of Investigation-Derived Waste from Borehole C4545 at the 216-A-8 Crib (2 Pages)

Waste Type	CIN[a]	PIN[b]	Project/ Well Number	Container Size	Waste Description	Date Sealed	Comments
IDW	0017980	PW3-05-001	C4545	55 gal	Soils 0-10 ft	06/06/05	<0.5 mR on contact; stored in CWCSA
IDW	0017948	PW3-05-002	C4545	55 gal	Soils 10-20 ft	06/08/05	35 mR on contact; 20 mR @ 30 cm; stored in RA
IDW	0017981	PW3-05-004	C4545	55 gal	Soils 20-23 ft	06/08/05	110 mR on contact; 50 mR @ 30 cm; overpacked in CIN #0021154; stored in RA
IDW	0021154	PW3-05-037	C4545	85 gal	Overpack for drum PW3-05-004	06/14/05	Overpack drum inside PW3-05-004; stored in RA
IDW	0018253	PW3-05-005	C4545	55 gal	Borehole cleanout (Soil) 23-23 ft	06/08/05	120 mR on contact; 70 mR @ 30 cm; overpacked in CIN #0022017; stored in RA
IDW	0022017	PW3-05-038	C4545	85 gal	Overpack for drum PW3-05-005	06/14/05	Overpack drum inside PW3-05-005; stored in RA
IDW	0018260	PW3-05-006	C4545	55 gal	Soils 23-25 ft and MSW	06/09/05	12 mR on contact; 4 mR @ 30 cm; stored in RMA
IDW	0018254	PW3-05-007	C4545	55 gal	Soils 25-31 ft	06/13/05	5 mR on contact; 1 mR @ 30 cm; stored in RMA
IDW	0018261	PW3-05-008	C4545	55 gal	Soils 31-34.5 ft and MSW	06/13/05	<0.5 mR on contact; stored in CWCSA
IDW	0018180	PW3-05-010	C4545	55 gal	Soils 34.5-41 ft and MSW	06/14/05	<0.5 mR on contact; stored in CWCSA
IDW	0018131	PW3-05-011	C4545	55 gal	Soils 41-49 ft and MSW	06/14/05	<0.5 mR on contact; stored in CWCSA
IDW	0018173	PW3-05-012	C4545	55 gal	Soils 49-57.5 ft	06/20/05	<0.5 mR on contact; stored in CWCSA
IDW	0018132	PW3-05-013	C4545	55 gal	Soils 57.5-62.5 ft	06/21/05	<0.5 mR on contact; stored in CWCSA
IDW	0018174	PW3-05-014	C4545	55 gal	Soils 62.5-66 ft	06/21/05	<0.5 mR on contact; stored in CWCSA
IDW	0018129	PW3-05-015	C4545	55 gal	Soils 66-69 ft	06/21/05	<0.5 mR on contact; stored in CWCSA
IDW	0018130	PW3-05-017	C4545	55 gal	Soils 69-79 ft	06/23/05	<0.5 mR on contact; stored in CWCSA
IDW	0018171	PW3-05-016	C4545	55 gal	Soils 79-89 ft	06/23/05	<0.5 mR on contact; stored in CWCSA
IDW	0018172	PW3-05-018	C4545	55 gal	Soils 89-99 ft	06/23/05	<0.5 mR on contact; stored in CWCSA
IDW	0018138	PW3-05-019	C4545	55 gal	Soils 99-117 ft	06/24/05	<0.5 mR on contact; stored in CWCSA
IDW	0018137	PW3-05-020	C4545	55 gal	Soils 117-124 ft	06/24/05	<0.5 mR on contact; stored in CWCSA

Table 2-5. Summary of Investigation-Derived Waste from Borehole C4545 at the 216-A-8 Crib (2 Pages)

Waste Type	CIN[a]	PIN[b]	Project/ Well Number	Container Size	Waste Description	Date Sealed	Comments
IDW	0025896	PW3-05-021	C4545	55 gal	Soils 124-135 ft	06/24/05	<0.5 mR on contact; stored in CWCSA
IDW	0025958	PW3-05-022	C4545	55 gal	Soils 135-147 ft	06/24/05	<0.5 mR on contact; stored in CWCSA
IDW	0025868	PW3-05-023	C4545	55 gal	Soils 147-154 ft	06/27/05	<0.5 mR on contact; stored in CWCSA
IDW	0025980	PW3-05-024	C4545	55 gal	Soils 154-164 ft	06/27/05	<0.5 mR on contact; stored in CWCSA
IDW	0025915	PW3-05-025	C4545	55 gal	Soils 164-175 ft	06/27/05	<0.5 mR on contact; stored in CWCSA
IDW	0025916	PW3-05-026	C4545	55 gal	Soils 175-186 ft	06/27/05	<0.5 mR on contact; stored in CWCSA
IDW	0025920	PW3-05-028	C4545	55 gal	Soils 186-196 ft	06/28/05	<0.5 mR on contact; stored in CWCSA
IDW	0025872	PW3-05-029	C4545	55 gal	Soils 196-207 ft	06/28/05	<0.5 mR on contact; stored in CWCSA
IDW	0025918	PW3-05-030	C4545	55 gal	Soils 207-221 ft	06/28/05	<0.5 mR on contact; stored in CWCSA
IDW	0025983	PW3-05-031	C4545	55 gal	Soils 221-230 ft	06/29/05	<0.5 mR on contact; stored in CWCSA
IDW	0025917	PW3-05-032	C4545	55 gal	Soils 230-241 ft	0629/05	<0.5 mR on contact; stored in CWCSA
IDW	0025982	PW3-05-033	C4545	55 gal	Soils 241-251 ft	06/29/05	<0.5 mR on contact; stored in CWCSA
IDW	0025919	PW3-05-034	C4545	55 gal	Soils 251-262 ft	06/30/05	<0.5 mR on contact; stored in CWCSA
IDW	0025984	PW3-05-035	C4545	55 gal	Soils 262 to 264 ft (total depth)	06/30/05	<0.5 mR on contact; stored in CWCSA

[a] CIN = container identification number (scannable barcode).
[b] PIN = primary drum identification number (written number).

CWCSA = Central Waste Container Storage Area.
DW = investigation-derived waste.
MSW = miscellaneous solid waste.
RA = Radiation Area.
RMA = Radioactive Materials Area.

3.0 SUBSURFACE DESCRIPTION

3.1 GEOLOGY OF THE 200 EAST AREA

Generalized stratigraphy in the 200 East Area near the 216-A-8 Crib includes a thin veneer of surficial sediments consisting of unconsolidated and unweathered Holocene aeolian sands and loess overlying unconsolidated sediments of the Hanford formation. The Hanford formation consists of Pleistocene-age cataclysmic flood and inter-flood deposits, consisting of a sand-dominated sequence (Unit 2) overlying a basal gravel-dominated sequence (Unit 3). Hanford formation sediments disconformably overlie sands and gravels of the Miocene to Pliocene Ringold Formation. The Ringold Formation, in descending order, consists of the Upper Ringold Unit (primarily gravelly sand), Unit "E" of the Ringold Formation (primarily sandy gravel), the Ringold lower mud (primarily silt and fine sand) and Unit "A" of the Ringold Formation (primarily sandy gravel). The Ringold Formation overlies flood basalt flows of the Miocene Columbia River Basalt Group. Basalts flows of the Elephant Mountain Member of the Saddle Mountains Basalt form the base of the suprabasalt aquifer.

The following section describes geology specific to Borehole C4545 at the 216-A-8 Crib.

3.2 GEOLOGY AT BOREHOLE C4545

The upper portion of the borehole encountered 0.5 m (1.5 ft) of crushed rock used to construct the drill pad, overlying crib construction backfill consisting of 1.4 m (4.5 ft) of gravelly sand, 2.1 m (7.0 ft) of sand, and 1.8 m (6.0 ft) of very coarse gravel. Although the proposed sample depths were adjusted by 0.3 m (1.0 ft) to account for the drill pad (see footnote to Table 2-2), it was determined that the pad thickness was actually 0.5 m (1.5 ft). However, no further adjustments to proposed sample depths were made.

Medium	Depth (m bgs)	Depth (ft bgs)
	Drill Pad	
Crushed rock	0.5	1.5
	Crib Construction Backfill	
Gravelly sand	1.4	4.5
Sand	2.1	7.0
Very coarse gravel	1.8	6.0

The interval beneath the crib construction backfill, extending from 5.8 to 54.3 m (19.0 to 178.0 ft) bgs, consists of well-stratified, very fine- to coarse-grained sands belonging to the sand-dominated facies of the Hanford formation (Unit 2). Several intervals contain finer-grained silty sands, including 14.0 to 14.2 m (46.0 to 46.5 ft) bgs, 30.2 to 31.7 m (99.0 to 104.0 ft) bgs, 36.3 to 37.5 m (119.0 to 123.0 ft) bgs, 38.7 to 42.1 m (127.0 to 138.0 ft) bgs, 48.3 to 49.4 m (158.5 to 162.0 ft) bgs, 50.6 to 51.2 m (166.0 to 168.0 ft) bgs, 51.4 to 52.1 m (168.5 to 171.0 ft) bgs, and 52.3 to 52.7 m (171.5 to 173.0 ft) bgs. Intervals containing coarser-grained gravelly sands include 14.6 to 16.8 m (48.0 to 55.0 ft) bgs and 52.7 to 54.3 m (173.0 to 178.0 ft) bgs. Intervals containing silty gravelly sand include 29.7 to 30.2 m (97.5 to 99.0 ft) bgs, 32.9 to 34.1 m (108.0 to 112.0 ft) bgs, 43.9 to 45.4 m (144.0 to 149.0 ft) bgs, and 45.7 to 46.6 m (150.0 to 153.0 ft) bgs. Intervals with silt include 51.2 to 51.4 m (168.0 to 168.5 ft) bgs and 52.1 to 52.3 m (171.0 to 171.5 ft) bgs.

Medium	Depth (m bgs)	Depth (ft bgs)
Finer-grained silty sands	14.0 to 14.2	46.0 to 46.5
	30.2 to 31.7	99.0 to 104.0
	36.3 to 37.5	119.0 to 123.0
	38.7 to 42.1	(127.0 to 138.0
	48.3 to 49.4	158.5 to 162.0
	50.6 to 51.2	166.0 to 168.0
	51.4 to 52.1	168.5 to 171.0
	52.3 to 52.7	171.5 to 173.0
Coarser-grained gravelly sands	14.6 to 16.8	48.0 to 55.0
	52.7 to 54.3	173.0 to 178.0
Silty gravelly sand	29.7 to 30.2	97.5 to 99.0
	32.9 to 34.1	108.0 to 112.0
	43.9 to 45.4	144.0 to 149.0
	45.7 to 46.6	150.0 to 153.0
Silt	51.2 to 51.4	168.0 to 168.5
	52.1 to 52.3	171.0 to 171.5

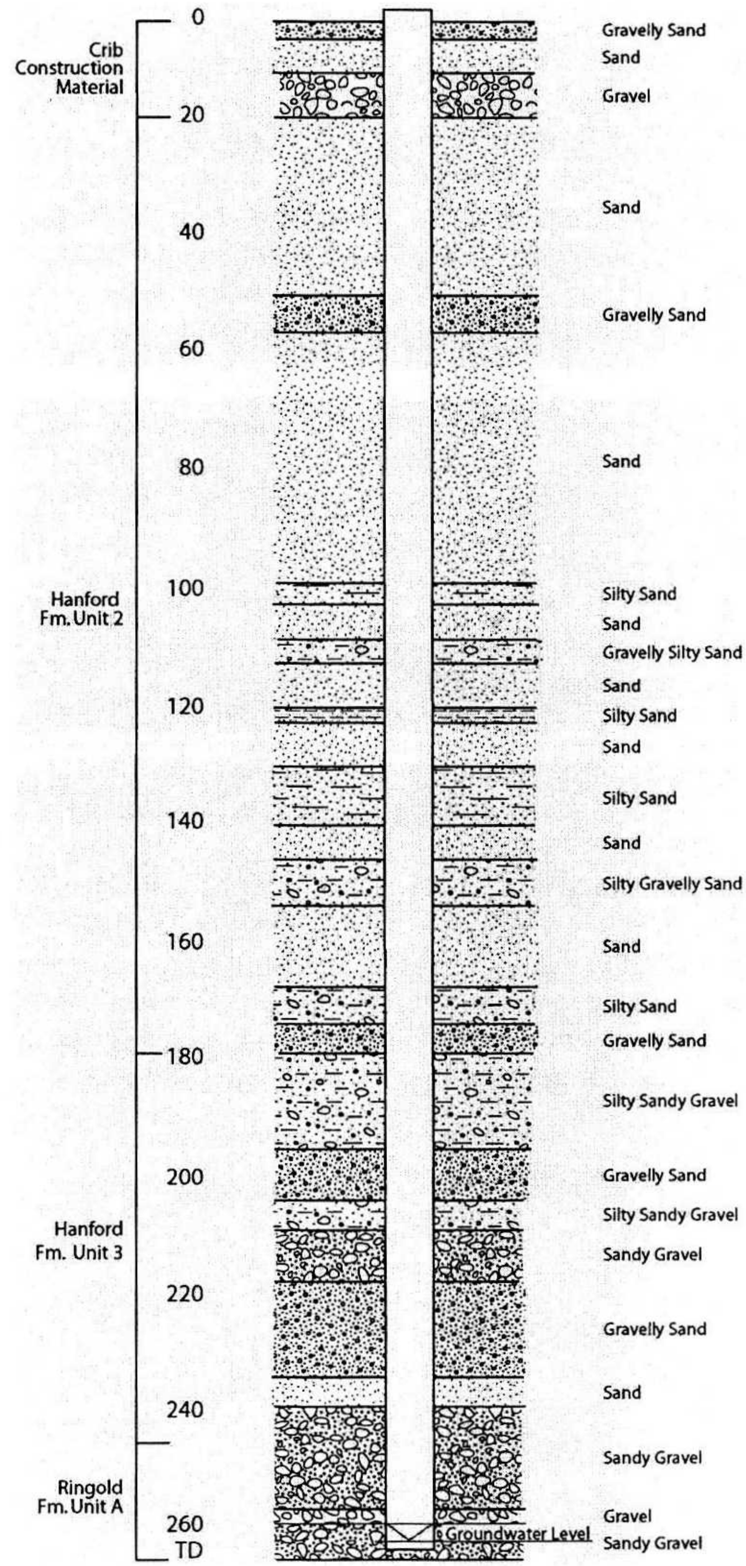
The interval from 54.3 to 74.8 m (178.0 to 245.5 ft) bgs consists of the gravel-dominated facies of the Hanford formation (Unit 3). These gravels consist of poorly sorted, angular to sub-rounded, heterolithic cobbles (basalts and other dominantly igneous lithologies). Cobbles range from small pebbles (4 to 6 mm) to large cobbles (64 to 256 mm). Intervals consisting of silty sandy gravel include 54.3 to 59.1 m (178.0 to 194.0 ft) bgs and 62.5 to 64.0 m (205.0 to 210.0 ft) bgs. Intervals containing gravelly sand include 59.1 to 62.5 m (194.0 to 205.0 ft) bgs, 66.3 to 67.7 m (217.5 to 222.0 ft) bgs, 67.8 to 68.6 m (222.5 to 225.0 ft) bgs, and 69.2 to 70.7 m (227.0 to 232.0 ft) bgs. Intervals consisting of sandy gravel include 64.0 to 66.3 m (210.0 to 217.5 ft) bgs, 68.6 to 69.2 m (225.0 to 227.0 ft) bgs, and 72.4 to 74.8 m (237.5 to 245.5 ft) bgs. The interval from 67.7 to 67.8 m (222.0 to 222.5 ft) bgs is a thin lens of silty sand, and the interval from 70.7 to 72.4 m (232.0 to 237.5 ft) bgs consists of sand.

Medium	Depth (m bgs)	Depth (ft bgs)
Silty sandy gravel	54.3 to 59.1	178.0 to 194.0
	62.5 to 64.0	205.0 to 210.0
Gravelly sand	59.1 to 62.5	194.0 to 205.0
	66.3 to 67.7	217.5 to 222.0
	67.8 to 68.6	222.5 to 225.0
	69.2 to 70.7	227.0 to 232.0
Sandy gravel	64.0 to 66.3	210.0 to 217.5
	68.6 to 69.2	225.0 to 227.0
	72.4 to 74.8	237.5 to 245.5
Thin lens of silty sand	67.7 to 67.8	222.0 to 222.5
Sand	70.7 to 72.4	232.0 to 237.5

The interval from 74.8 to 80.6 m (245.5 to 264.5 ft) bgs (total depth) consists of sandy gravels of the Ringold Formation Unit A. These sediments consist of clast- to matrix-supported pebble (2 to 64 mm) to cobble (64 to 256 mm) heterolithic gravels with a fine- to coarse-grained sandy matrix. Lenticular sand and silt interbeds also are characteristic of the Ringold Formation Unit A.

Figure 3-1 illustrates the geology at Borehole C4545, and Appendix E contains the borehole log for Borehole C4545.

Figure 3-1. Summary of Borehole Geology at Borehole C4545.



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APPENDIX A

216-A-8 CRIB SOIL VAPOR SAMPLING IN DIRECT-PUSH BOREHOLES

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APPENDIX A

216-A-8 CRIB SOIL VAPOR SAMPLING IN DIRECT-PUSH BOREHOLES

On July 7 and July 8, 2004, in situ soil-vapor sampling was conducted along the length of the 216-A-8 Crib, in accordance with guidance provided by DOE/RL-2001-01, *Plutonium/Organic-Rich Process Condensate/Process Waste Group Operable Unit RI/FS Work Plan, Includes: 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units*, Appendix B, the sampling and analysis plan. A direct-push technology, the GeoProbe[1], was used to install boreholes for access to the shallow vadose zone, and soil-vapor samples were collected from the bottom of each borehole. The borehole locations are shown in Figure A-1.

Installation of the five boreholes started at the western end of the crib and proceeded toward the eastern end. The sequence for borehole installation was C4544, C4543, C4542, C4541, and C4540. Installation of three direct-push boreholes (C4542, C4543, and C4544) occurred on July 7, 2004, and installation of the remaining two boreholes (C4540 and C4541) took place on July 8, 2004. Four boreholes (C4541, C4542, C4543, and C4544) were pushed to a depth of 4.7 m (15.3 ft) below ground surface (bgs). Borehole C4540 was pushed to refusal at 3.7 m (12.3 ft) bgs.

After each borehole reached final depth, the casing string was retracted for 0.3 m (1 ft) to provide a 0.3 m (1-ft)-long open sampling interval. A metal mesh screen attached to TYGON[2] tubing then was lowered into the hole until it reached bottom. A seal around the tubing at the top of the hole was formed by inserting a nitrile glove into the casing and taping over the top with electrical tape. The end of the tubing was connected to a Thermo Environmental Instruments Inc. Model 580S organic vapor monitor (OVM) (serial # 580S-57818-315)[3] calibrated with isobutylene calibration gas with a known concentration of 104 ppm. The OVM was used to pump the vapor through the tubing to the surface.

Planning, drilling, and decommissioning of the direct-push GeoProbe boreholes adhered to the guidelines and requirements presented in GRP-EE-02-14.2 (*GeoProbe, Casing Driving, and Push Technology Installations)*. The GeoProbe boreholes conformed to standards defined in WAC-173-160 (*Minimum Standards for Construction and Maintenance of Wells*).

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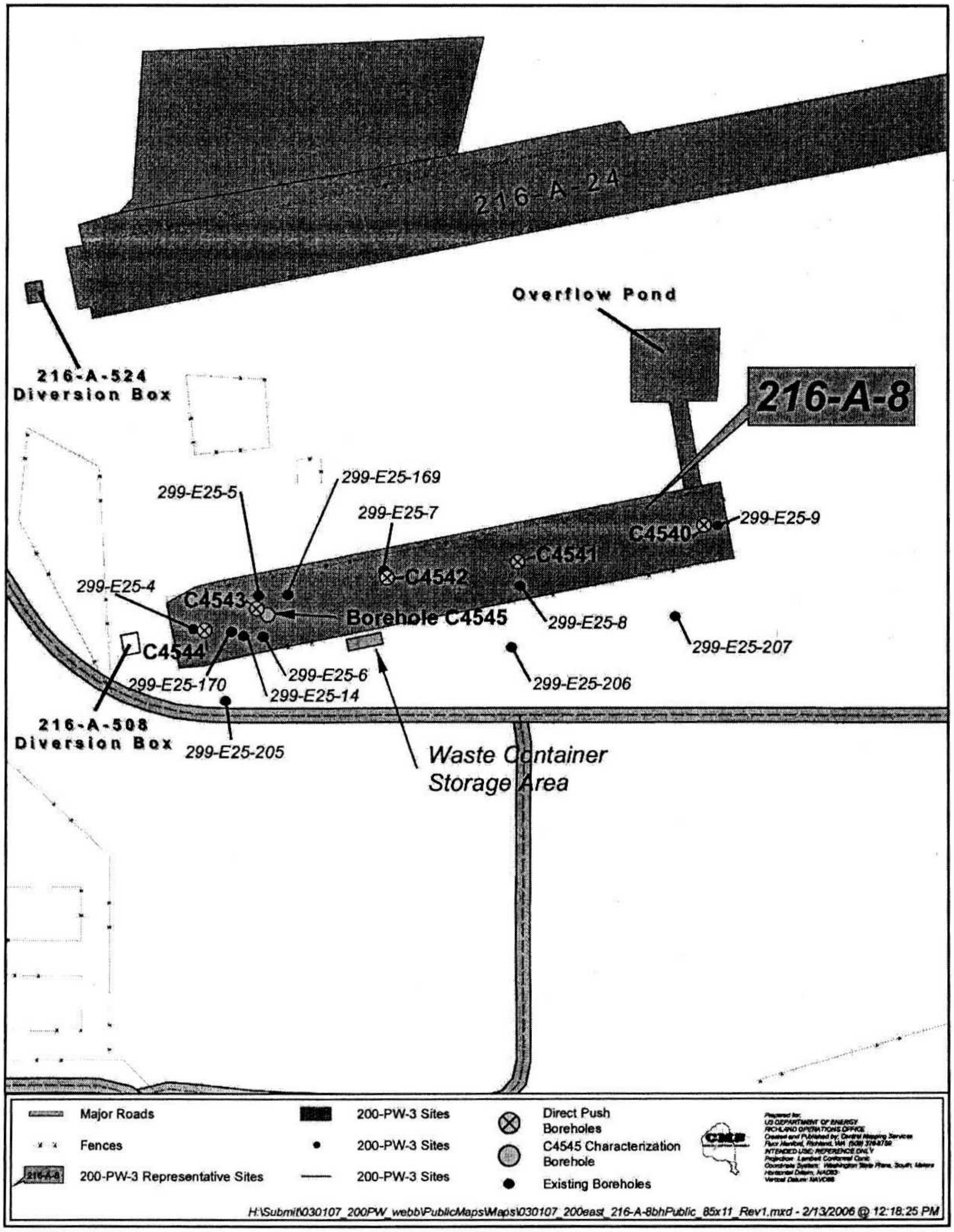
[1] GeoProbe is a registered trademark of GeoProbe Systems, Salina, Kansas.

[2] TYGON is a registered trademark of Norton Performance Plastics Corporation, a Saint-Gobain Company, Akron, Ohio.

[3] Thermo Environmental is an abbreviation for Thermo Electron Corporation, Environmental Instruments Division, Franklin, Massachusetts, of which Model 580S is a trademark.

Figure A-1. Location of Direct-Push (GeoProbe) Boreholes and Existing Wells at the 216-A-8 Crib.



The OVM initially was operated for at least 5 minutes to exhaust air from the void space of the casing. The casing had an inside diameter of approximately 2.5 cm (1 in.) and was 4.9 m (16 ft) in length, resulting in an internal volume of approximately 2458 cm^3 (150 in^3) or 2.5 L. The OVM pump extracts approximately 0.5 to 1 L per minute, so 5 minutes of operation, assuming extraction at the lower pumping rate, was considered sufficient to exhaust any atmospheric air introduced into the casing and allow sampling of in situ soil vapor. Following the 5-minute purge of the borehole, the OVM was used to measure the concentration of organic compounds in the soil vapor. A soil-vapor sample then was collected in a Tedlar[4] bag for field screening using an Innova[5] multigas analyzer and a Photovac 10S Plus[6] gas chromatograph. The Innova multigas analyzer and the gas chromatograph are calibrated to identify individual organic compounds, whereas the OVM can measure only the total organic concentration.

The OVM then was removed from the tubing, and the end of the tubing was capped to prevent introduction of atmospheric air into the system. Dräger[7] tubes (colorimetric indicator tubes) then were attached to the end of the tubing, and samples were drawn through the tubes by using a bellows style pump (Dräger 2001, *Dräger-Tubes/CMS Handbook*). Four specific types of Dräger tubes, described below, were selected to cover the range of organic contaminants that might be present, in addition to the volatile organic compounds that could be analyzed using the gas chromatograph and Innova analyzer.

A Dräger tube is a glass vial containing a chemical preparation that is designed to react with a specific compound and change color. Drawing a specified volume of soil vapor through the glass vial and reagent substrate allows the reagent substrate to undergo the chemical reaction and produce the color change, if the specific compound is present in the soil vapor. On tubes with gradational markings, the length of the resulting color change correlates to the concentration of the specific substance in the soil vapor, and the concentration is read directly from gradational markings on the tube. On tubes without gradational markings, color changes only indicate the presence of the specific substance. However, these tubes provide a qualitative indication of the relative amount of the substance present through either the length of the discoloration or the intensity of the color change. Dräger tubes allow on-the-spot measurement at a given location over a relatively short period. They are sealed until use, have a shelf life of about 2 years, and require no user calibration. The results are accurate for tubes with and without gradational markings. Following is a discussion of the four types of tubes employed at the 216-A-8 Crib.

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[4] Tedlar is a registered trademark of E. I. du Pont de Nemours and Company, Wilmington, Delaware.

[5] Innova is a trademark of Innova AirTech Instruments A/S, Ballerup, Denmark.

[6] Photovac 10S Plus is a trademark of Photovac, Inc., Waltham, Massachusetts.

[7] Dräger is a trademark of OFI Testing Equipment, Inc., Houston, Texas. (aka OFITE)

•<u>Hydrocarbon 0.1%/b</u> - The tube contains iodine pentoxide (I_2O_5), which reacts with hydrocarbons to produce iodine, manifested by a color change from white to brown gray. It is primarily an indicator of hydrocarbons with double bonds, such as propane/butane (C_3H_8/C_4H_{10}). The general reaction is as follows:

$$C_3H_8 / C_4H_{10} + I_2O_5 \rightarrow I_2.$$

Propane has a measurement range of 0.1 to 0.8 vol%, and butane has a measurement range of 0.5 to 1.3 vol%. The standard deviation is ± 30 to 40%.

•<u>Hydrocarbon 2</u> - The tube contains selenium dioxide (SeO_2), which reacts with hydrocarbons (C_8H_{18}) to produce a color change from pale yellow to brown. This reagent indicates both aliphatic and aromatic hydrocarbons, although aromatic hydrocarbons produce a more reddish color change. The general reaction is as follows:

$$C_8H_{18} + SeO_2 \rightarrow \text{brown reaction product.}$$

Octane has a measurement range of 3 to 23 (mg/L hydrocarbon)/L. The standard deviation is ± 30 to 40%.

•<u>Polytest</u> - The tube contains iodine pentoxide, which reacts with easily oxidized compounds to produce a color change from white to brown, green, or possibly violet, depending on the substances present. The reaction principle is as follows:

$$CO + I_2O_5 \rightarrow I_2 + CO_2.$$

This tube provides a qualitative screening test for the presence or absence of a number of compounds, including acetone, acetylene, arsine, benzene, butane, carbon monoxide, carbon disulfide, ethylene, hydrogen sulfide, octane, perchloroethylene, propane, styrene, and toluene/xylene. The presence of several substances can be indicated when individual concentrations exceed the following levels:

2000 ppm Acetone	10 ppm Acetylene	1 ppm Arsine
50 ppm Benzene	100 ppm Butane	5 ppm Carbon monoxide
1 ppm Carbon disulfide	50 ppm Ethylene	2 ppm Hydrogen sulfide
10 ppm Octane	20 ppm Perchloroethylene	500 ppm Propane
10 ppm Styrene	10 ppm Toluene/Xylene	

This tube does not provide indications for methane, ethane, hydrogen and carbon dioxide.

•<u>Ammonia 5/a</u> - The tube contains a pH indicator that reacts with ammonia (NH_3) to produce a color change from yellow orange to blue. There is no interference by up to 300 ppm of nitrous gases (NOx), 2000 ppm of sulfur dioxide, and 2000 ppm of hydrogen sulfide. The tube also detects organic amine compounds. The general reaction is as follows:

$$\text{pH indicator} + NH_3 \rightarrow \text{blue reaction product.}$$

Ammonia has a measurement range of 5 to 70 ppm with a standard deviation of ± 10 to 15%. Detection below 5 ppm is possible, but only as a qualitative indication.

Table A-1 lists the borehole, interval sampled (between the depth of total push and depth of casing bottom after back-pulling 0.3 m [1 ft]), and OVM reading (in parts per million). The next four columns list the results of testing using the ammonia, polytest, hydrocarbon 0.1%/b, and hydrocarbon 2 Dräger tubes.

Table A-2 lists the analytical results for soil vapor samples that were collected in Tedlar bags and analyzed using the gas chromatograph and the Innova analyzer. Two duplicate samples, one on each day of sampling, also were collected in Tedlar bags and analyzed as part of this process. Calibration checks using a set of standards were performed before analysis began and at the end of analysis each day. Table A-2 shows that most variances from the standards were less than 10 percent. A blank sample consisting of certified clean air also was analyzed each day. The sample holding time of six hours was exceeded for four samples, including both duplicate samples and one of the original samples used as part of the original / duplicate quality control pair. The close correlation between the results for the original sample that did not exceed the hold time and the duplicate that did exceed the hold time suggests that exceeding the hold time may not have affected the sample results.

Table A-1. Field Screening Results for In Situ Soil Vapor Samples Analyzed using the Organic Vapor Monitor and Dräger Tubes.

Borehole	Sample Date	Sample Interval (ft)	Depth to Gravel (ft)	OVM (ppm)	Dräger Tubes			
					Ammonia	Polytest	Hydro-carbon 0.1%/b	Hydro-carbon 2
C4544	07/07/2004	14.3 - 15.3	N/A	0.3 - 0.5	ND	ND	ND	Trace
C4543	07/07/2004	14.3 - 15.3	12	2	ND	ND	ND	ND
C4542	07/07/2004	14.3 - 15.3	12	0	ND	ND	ND	ND
C4541	07/08/2004	14.3 - 15.3	11	0.5 - 0.7	ND	ND	ND	ND
C4540	07/08/2004	11.3 - 12.3	8	0.3	ND	ND	Trace	ND

ND = not detected.
OVM = organic vapor monitor.
Trace = slight change noted.

The only soil-vapor samples that showed Dräger tube test reactions were from Boreholes C4544 and C4540, and the reactions were weak trace reactions in both cases (Table A-1). Tubes used in the sampling were checked on July 8, 2004, to determine if they were functioning correctly, by drawing vapor from the exhaust of a diesel engine and the smoke from a cigarette. Both of these tests produced positive indications of reaction on the tubes. No volatile organic compounds were detected in the soil-vapor samples analyzed using the gas chromatograph or the Innova analyzer (Table A-2). Only trace quantities of organic contamination were detected using the OVM (Table A-1).

Table A-2. Industrial Hygiene Survey Results for 216-A-8 GeoProbe Boreholes.

Borehole	Location Tested	NH_3 (ppm)	Volatile Organics (ppm)	O_2 (%)
C4544	Breathing Zone	<D	<D	20.8
C4544	Point Source	<D	<D	20.8
C4543	Breathing Zone	2.1	<D	21.3
C4543	Point Source	20.8	0.03	20.9
C4542	Breathing Zone	<D	<D	21.0
C4542	Point Source	22.1	0.04	19.5
C4541	Breathing Zone	<D	<D	20.9
C4541	Point Source	<D	<D	20.9
C4540	Breathing Zone	<D	<D	21.0
C4540	Point Source	<D	<D	21.2

<D = less than detect.
NH_3 = ammonia.
O_2 = oxygen.

Health and safety monitoring was conducted by the industrial hygiene technician during installation, sampling, and decommissioning activities at the five GeoProbe boreholes. Monitoring included breathing-zone and point-source readings for volatile organics, ammonia, and combustible gases. The industrial hygiene technician detected contaminants in the open casing at Boreholes C4543 and C4542 immediately after the casing was back-pulled to expose the sampling interval, and the back-pull tool was removed from the top of the casing (Table A-3). These initial concentrations quickly dissipated. Instruments used for monitoring were a VX500 PhotoIonization Detector[8] for ammonia and organics, Industrial Scientific TMX412 Multi-Gas Monitor[9] for O_2 and lower explosive limit, and Manning EC-P2[10] ammonia meter.

[8] VX500 PhotoIonization Detector is a trademark of Industrial Scientific Corporation, Oakdale, Pennsylvania.

[9] TMX412 Multi-Gas Monitor is a trademark of Industrial Scientific Corporation, Oakdale, Pennsylvania.

[10] Manning EC-P2 is a trademark of Manning Systems Incorporated, Lenexa, Kansas.

Samples Collected in Tedlar Bags and Analyzed with a Gas Chromatograph and an Innova Multigas Analyzer.

Photovac 10S Plus Gas Chromatograph								Innova Multigas Analyzer		
DCM[3] (ppm-v/v)	1,1-DCA[4] (ppm-v/v)	TCM[5] (ppm-v/v)	1,1,1-TCA[6] (ppm-v/v)	CCl4[7] (ppm-v/v)	TCE[8] (ppm-v/v)	1,1,2-TCA[9] (ppm-v/v)	PCE[10] (ppm-v/v)	CCl_4 (ppm-v/v)	TCM (ppm-v/v)	Water Vapor (ppm-v/v)
1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	25.5	---	---
NA	0.96	0.97	0.98	1.01	0.96	NA	0.98	22.5	---	---
<0.10	<0.25	<0.20	<0.15	<0.20	<0.10	<0.10	<0.25	<1.0	<1.0	9,200
<0.10	<0.25	<0.20	<0.15	<0.20	<0.10	<0.10	<0.25	<1.0	<1.0	8,150
<0.10	<0.25	<0.20	<0.15	<0.20	<0.10	<0.10	<0.25	<1.0	<1.0	8,220
<0.10	<0.25	<0.20	<0.15	<0.20	<0.10	<0.10	<0.25	<1.0	<1.0	8,180
<0.10	<0.25	<0.20	<0.15	<0.20	<0.10	<0.10	<0.25	<1.0	<1.0	8,150
NA	0.95	0.97	0.96	1.00	0.96	NA	0.97	22.5	---	---
1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	25.5	---	---
NA	0.95	0.91	0.94	0.94	0.96	NA	1.01	22.6	---	---
<0.10	<0.25	<0.20	<0.15	<0.20	<0.10	<0.10	<0.25	<1.0	<1.0	8,300
<0.10	<0.25	<0.20	<0.15	<0.20	<0.10	<0.10	<0.25	<1.0	<1.0	12,600
<0.10	<0.25	<0.20	<0.15	<0.20	<0.10	<0.10	<0.25	<1.0	<1.0	9,100
<0.10	<0.25	<0.20	<0.15	<0.20	<0.10	<0.10	<0.25	<1.0	<1.0	9,200
NA	0.93	0.90	0.91	0.83	0.91	NA	0.89	22.6	---	---

[6] 1,1,1-trichoroethane.

[7] carbon tetrachloride.

[8] trichloroethylene.

[9] 1,1,2-trichloroethane.

[10] tetrachloroethylene.

Table A-2. Field Screening Results for Samples Collected in Tedlar Bags and Analyzed with a Gas Chromatograph and an Innova Multigas Analyzer.

Sample Identifier	HEIS No.	Sample Date	Sample Time	Analysis Date	Analysis Time	Photovac 10S Plus Gas Chromatograph								Innova Multigas Analyzer		
						DCM[3] (ppm-v/v)	1,1-DCA[4] (ppm-v/v)	TCM[5] (ppm-v/v)	1,1,1-TCA[6] (ppm-v/v)	CCl4[7] (ppm-v/v)	TCE[8] (ppm-v/v)	1,1,2-TCA[9] (ppm-v/v)	PCE[10] (ppm-v/v)	CCl_4 (ppm-v/v)	TCM (ppm-v/v)	Water Vapor (ppm-v/v)
Calibration Standard	---	---	---	---	---	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	25.5	---	---
Calibration Check	---	07/07/2004	16:55	07/07/2004	17:24	NA	0.96	0.97	0.98	1.01	0.96	NA	0.98	22.5	---	---
Blank (Certified Clean Air)	---	07/07/2004	16:35	07/07/2004	17:30	<0.10	<0.25	<0.20	<0.15	<0.20	<0.10	<0.10	<0.25	<1.0	<1.0	9,200
C4542	B19V36	07/07/2004	13:05	07/07/2004	17:35	<0.10	<0.25	<0.20	<0.15	<0.20	<0.10	<0.10	<0.25	<1.0	<1.0	8,150
C4543	B19V37*	07/07/2004	10:50	07/07/2004	17:41	<0.10	<0.25	<0.20	<0.15	<0.20	<0.10	<0.10	<0.25	<1.0	<1.0	8,220
C4544	B19V38*	07/07/2004	9:40	07/07/2004	17:47	<0.10	<0.25	<0.20	<0.15	<0.20	<0.10	<0.10	<0.25	<1.0	<1.0	8,180
C4544 Duplicate	B19V39*	07/07/2004	9:40	07/07/2004	17:53	<0.10	<0.25	<0.20	<0.15	<0.20	<0.10	<0.10	<0.25	<1.0	<1.0	8,150
Calibration Check	---	07/07/2004	16:55	07/07/2004	18:00	NA	0.95	0.97	0.96	1.00	0.96	NA	0.97	22.5	---	---
Calibration Standard	---	---	---	---	---	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	25.5	---	---
Calibration Check	---	07/08/2004	12:25	07/08/2004	12:57	NA	0.95	0.91	0.94	0.94	0.96	NA	1.01	22.6	---	---
Blank (Certified Clean Air)	---	07/08/2004	12:15	07/08/2004	13:05	<0.10	<0.25	<0.20	<0.15	<0.20	<0.10	<0.10	<0.25	<1.0	<1.0	8,300
C4540	B19V43	07/08/2004	13:15	07/08/2004	14:07	<0.10	<0.25	<0.20	<0.15	<0.20	<0.10	<0.10	<0.25	<1.0	<1.0	12,600
C4541	B19V44	07/08/2004	8:15	07/08/2004	14:13	<0.10	<0.25	<0.20	<0.15	<0.20	<0.10	<0.10	<0.25	<1.0	<1.0	9,100
C4541 Duplicate	B19V45*	07/08/2004	8:15	07/08/2004	14:20	<0.10	<0.25	<0.20	<0.15	<0.20	<0.10	<0.10	<0.25	<1.0	<1.0	9,200
Calibration Check	---	07/08/2004	12.25	07/08/2004	14:27	NA	0.93	0.90	0.91	0.83	0.91	NA	0.89	22.6	---	---

[1] Instrument: Photovac 10S Plus GC, Serial # TA920107.
[2] Instrument: Innova 1312 photoacoustic multigas analyzer, Serial # A9720.
[3] dichloromethane.
[4] 1,1-dichloroethane.
[5] trichloromethane.
* Analysis conducted after 6-hour hold time was exceeded.

[6] 1,1,1-trichoroethane.
[7] carbon tetrachloride.
[8] trichloroethylene.
[9] 1,1,2-trichloroethane.
[10] tetrachloroethylene.

Innova is a trademark of Innova AirTech Instruments A/S, Ballerup, Denmark.
Photovac 10S Plus is a trademark of Photovac, Inc., Waltham, Massachusetts.
NA = not analyzed.

Following collection of the Dräger tube samples, the sampling tube was removed from the borehole. Each borehole then was decommissioned by being filled with bentonite granules and chips. Bentonite was poured through the temporary casing as it was being extracted to ensure overlap during withdrawal.

The radiological control technician wiped the tubing and filter with a cloth as it was retrieved, to monitor for potential radiological contamination. Radiological field screening was conducted by a radiological control technician on the GeoProbe rods as they were withdrawn from the subsurface.

The metal mesh screens from boreholes C4542 and C4541 were radiologically contaminated, indicating that radioactive contamination was encountered at the bottom of these boreholes. Contamination on the probe at borehole C4542 was initially 6,000 cpm $\beta\gamma$, with 3,500 cpm $\beta\gamma$ removable. The screen and approximately 0.3 m (1 ft) of tubing were removed and bagged as contaminated material. The radiological control technician was concerned that the removable contamination could become airborne if exposed to the windy conditions, so a Radiological Work Permit was required for removal of the casing. Because it was near the end of the work day, it was determined to seal the top of the casing with tape, mark it with a trefoil, and remove it the next day.

Contamination levels on the metal mesh screen from Borehole C4541 were 40,000 cpm $\beta\gamma$. The sampling screen and approximately 0.5 m (1.5 ft) of tubing were removed, bagged, and disposed of as contaminated material. The Radiological Work Permit controlled the work.

No radiological contamination was detected on the GeoProbe rods.

Borehole C4541 exhibited venting of dust for approximately 5 seconds upon removal of the back-pulling tool. The open interval at this time was from 4.4 to 4.7 m (14.3 to 15.3 ft) bgs. A grinding sound of metal on rock was reported when the casing was back-pulled at this borehole.

Table A-4 lists the civil survey data (northing and easting coordinates and elevation) for each borehole.

Table A-4. GeoProbe Borehole Civil Survey Data.

Borehole	Northing (m)	Easting (m)	Ground Elevation (m)
C4544	136169.31	575650.97	202.01
C4543	136177.37	575682.22	201.62
C4542	136191.62	575747.08	201.39
C4541	136202.24	575813.83	201.50
C4540	136219.37	575911.73	200.80

Datum:
NAD83, 1991, *North American Datum of 1983.*
NAVD88, 1988, *North American Vertical Datum of 1988.*

REFERENCES

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Dräger, 2001, *Dräger-Tubes/CMS Handbook*, 12th ed., Dräger Safety AG & Co., Lübeck, Germany.

GRP-EE-02-14.2, *GeoProbe, Casing Driving, and Push Technology Installations,* Fluor Hanford, Inc., Richland, Washington.

NAD83, 1991, *North American Datum of 1983*, National Geodetic Survey, Federal Geodetic Control Committee, Silver Spring, Maryland, as revised.

NAVD88, 1988, *North American Vertical Datum of 1988*, National Geodetic Survey, Federal Geodetic Control Committee, Silver Spring, Maryland.

WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

APPENDIX B

216-A-8 CRIB SOIL VAPOR SAMPLING IN EXISTING BOREHOLES

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APPENDIX B

216-A-8 CRIB SOIL VAPOR SAMPLING IN EXISTING BOREHOLES

Soil vapor sampling in five existing boreholes at the 216-A-8 Crib took place on April 21, 2005. Soil-vapor samples were collected from the screened zones at wells 299-E25-4, 299-E25-5, 299-E25-7, 299-E25-8, and 299-E25-9, in accordance with guidance provided in DOE/RL-2001-01, *Plutonium/Organic-Rich Process Condensate/Process Waste Group Operable Unit RI/FS Work Plan, Includes: 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units*, Appendix B, the sampling and analysis plan. The screened zone in each well was isolated using a downhole packer. The samples were analyzed for volatile- and semivolatile-organic compounds using a field screening instrument. Figure B-1 shows the location of these wells.

The samples were analyzed using a MIRAN SapphIRe[1] Ambient Air Analyzer. The MIRAN SapphIRe uses a single-beam infrared spectrophotometer coupled with a microcontroller that automatically controls the analysis, processes the measurement signal, and calculates the absorbance values.

Initial operation of the MIRAN SapphIRe in spectrum scan mode allowed scanning of all measurable wavelengths. At all five wells, the spectrum scan was set for "full scan – L". This is the setting for a spectrum scan using a long signal pathlength. The full scan also provides signal compensation to reduce signal noise generation in the data file. The duration of this type of scan is 400 seconds.

The scan was stored in internal memory until downloaded to a laptop computer in the field. The laptop computer contains a program, ThermoMatch[2], which analyzes the data file and determines correlations between known compounds or combinations of known compounds and the actual scan. The correlation is assigned a Hit Quality Index (HQI) to indicate the degree of certainty that each of up to five detected compounds may be contributing to the unknown scan. HQI comments include the following:

- >90% = Excellent hit quality (90-100% HQI)
- 80-90% = Good hit quality (80-90% HQI)
- 70-80% = Fair hit quality (70-80% HQI)
- <70% = Poor hit quality (0-70% HQI).

Table B-1 lists the compounds that are in the ThermoMatch software library for use in scan analysis comparisons.

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[1] MIRAN and the SapphIRe Ambient Air Analyzer are registered trademarks of Thermo Electron Corporation, Franklin, Massachusetts.

[2] ThermoMatch is a trademark of Thermo Electron Corporation, Waltham, Massachusetts.

Figure B-1. Location of Existing Boreholes at the 216-A-8 Crib.

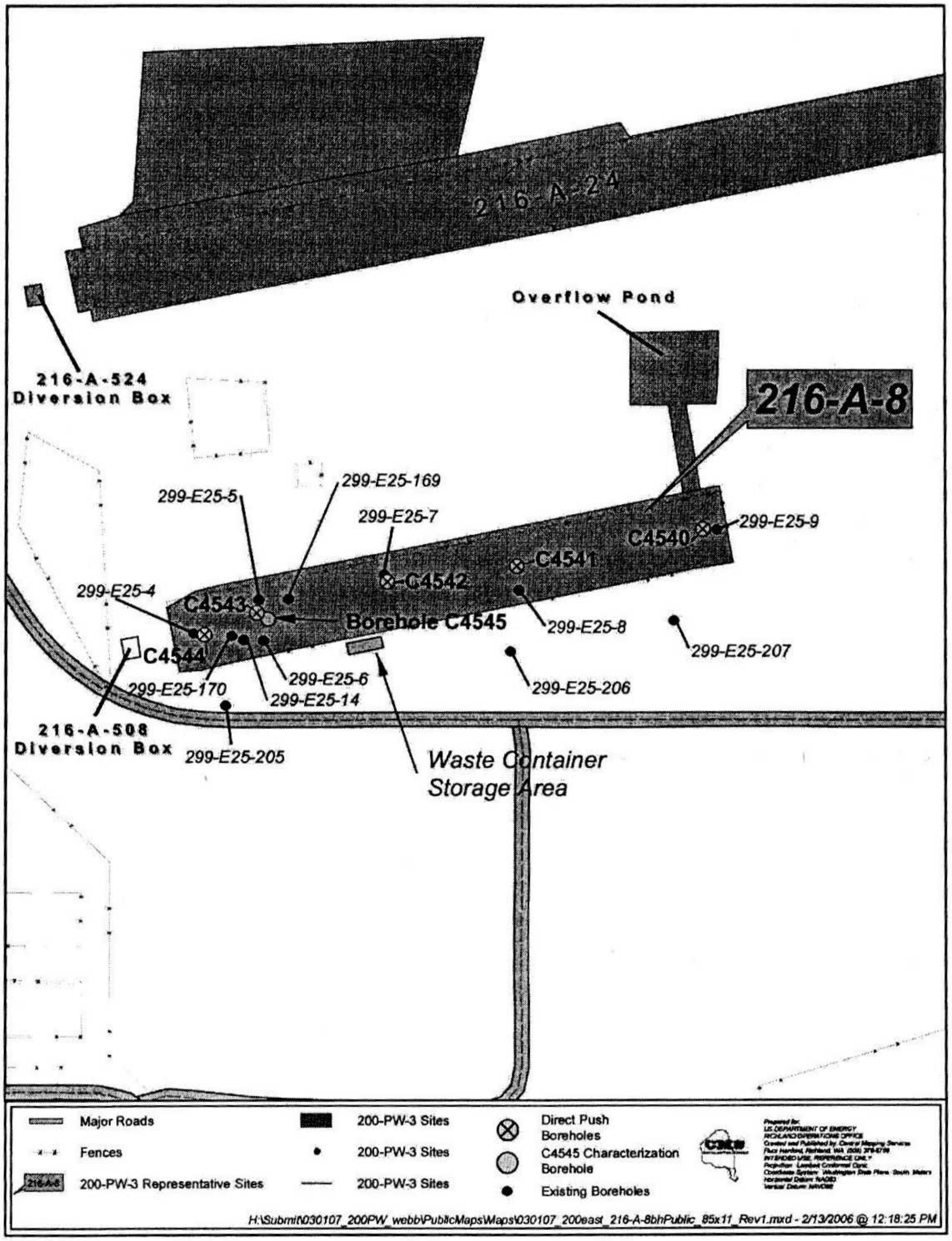

Table B-1. ThermoMatch Library Compounds. (2 Pages)

Compound Name	CAS #	Compound Name	CAS #	Compound Name	CAS #
1,1,1,2-Tetrachloroethane	630-20-6	Dichloroethylether	111-44-4	Methyl Pyrrolidinone, n-	872-50-4
1,1,2,2-Tetrachloroethane	79-34-5	Dichloroethylethylether	623-46-1	Methyl Salicylate	119-36-8
1,1,2-Trichloroethane	79-00-5	Dichlorotrifluoroethane	306-83-2	Methylene Chloride	75-09-2
1,1-Dichloroethane	75-34-3	Diethyl Ether	60-29-7	Methylene Fluoride	75-10-5
1,2-Dichloroethene,trans-	156-60-5	Diethyl Malonate	105-53-3	MIBK	108-10-1
1,2-Dichloroethylene,cis-	156-59-2	Diethylamine	109-89-7	Nitrobenzene	98-95-3
1,3-Butadiene	106-99-0	Dimethyl Carbonate	616-38-6	Nitrogen Trifluoride	7783-54-2
1,1,1,2,3,3,3-Heptafluoropropane	431-89-0	Dimethyl Sulfate	77-78-1	Nitrous Oxide	10024-97-2
1-Bromobutane	109-65-9	Dimethyl Sulfoxide	76-78-5	Octane	111-65-9
1-Octanethiol	111-88-6	Dimethylacetamide	127-19-5	Octanol	104-76-7
1-Octene	111-66-0	Dioxane	123-91-1	Pentane	109-66-0
2-Chlorotoluene	95-49-8	DPGME	34590-94-8	PGME	107-98-2
2-Furfural	98-01-1	Enflurane	13838-16-9	PGMEA	108-65-6
Acetaldehyde	75-07-0	Epichlorohydrin	106-89-8	Phosgene	75-44-5
Acetic Acid	64-19-7	Ethane	74-84-0	Propane	74-98-6
Acetone	67-64-1	Ethyl Acetate	141-78-6	Propanol, n-	71-23-8
Acetonitrile	75-05-8	Ethyl Alcohol	64-17-5	Propyl Bromide, n-	106-94-5
Acetophenone	98-86-2	Ethyl Benzene	100-41-4	Propylene Oxide	75-56-9
Acetyl Chloride	75-36-5	Ethyl Chloride	75-00-3	Pyridine	40-86-1
Acetylene	74-86-2	Ethyl Formate	109-94-9	R-113	76-13-1
Acrolein	107-02-8	Ethyl Lactate	97-64-3	R-114	76-14-2
Acrylonitrile	107-13-1	Ethyl Mercaptan	75-08-1	R-12	75-71-8
Allyl Chloride	107-05-1	Ethylene	74-85-1	R-124	2837-89-0
Ammonia	7664-41-7	ETO	75-21-8	R-125	354-33-6
Amyl Alcohol	71-41-0	Formaldehyde	50-00-0	R-134A	811-97-2
Aniline	62-53-3	Formic Acid	64-18-6	R-13B1	75-63-8
Benzaldehyde	100-52-7	Halothane	151-67-7	R-14	75-73-0
Benzene	71-43-2	Heptane	142-82-5	R-142B	75-68-3
Benzyl Alcohol	100-51-6	Hexafluoroisobutylene	382-10-5	R-143A	420-46-2
Benzyl Chloride	100-44-7	Hexafluoropropylene	116-15-4	R-152A	75-37-6
Butane	106-97-8	Hexamethyldisilazane	999-97-3	R-21	75-43-4
Butanol, n-	71-36-3	Hexanes	73513-42-5	R-22	75-45-6
Butyl Acetate	123-86-4	Hydrazine	302-01-2	R-23	75-46-7
Butyl Cellosolve	111-76-2	Isobutane	75-28-5	R-236FA	690-39-1
Butyl Methyl Ether, t-	1634-04-4	Isobutyl Acetate	110-19-0	Sevoflurane	28523-86-6
Carbon Dioxide	124-38-9	Isoflurane	26675-46-7	SF6	2551-62-4

Table B-1. ThermoMatch Library Compounds. (2 Pages)

Compound Name	CAS #	Compound Name	CAS #	Compound Name	CAS #
Carbon Disulfide	75-15-0	Isopropyl Alcohol	67-63-0	Styrene	100-42-5
Carbon Tetrachloride	56-23-5	Isopropyl Ether	108-20-3	Sulfur Dioxide	7446-09-5
Cellosolve	110-80-5	m-Cresol	108-39-4	Sulfuryl Fluoride	2669-79-8
Cellosolve Acetate	111-15-9	Methane	74-82-8	t-Butyl Alcohol	75-65-0
Chlorobenzene	108-90-7	Methoxyflurane	76-38-0	Tetrachloroethylene	127-18-4
Chloroform	67-66-3	Methyl Acetate	79-20-9	Tetrahydrofuran	109-99-9
Chlorotrifluoroethane	1330-45-6	Methyl Acetylene	74-99-7	Toluene	108-88-3
Chlorotrifluoroethylene	79-01-6	Methyl Acrylate	96-33-3	Trichloroethylene	79-01-6
Carbon Monoxide	630-08-0	Methyl Alcohol	67-56-1	Trichlorofluoromethane	75-69-4
Cumene	98-82-8	Methyl Amine	74-89-5	Triethylamine	75-50-3
Cyclohexane	110-82-7	Methyl Cellosolve	109-86-4	Trifluorochloroethylene	79-38-9
Cyclohexanol	108-93-0	Methyl Cellosolve Acetate	110-49-6	Vinyl Acetate	108-05-4
Desflurane	57041-67-5	Methyl Chloride	74-87-3	Vinyl Chloride	75-01-4
Diacetone Alcohol	123-42-2	Methyl Chloroform	71-55-6	Vinyl Fluoride	75-02-5
Dichlorobenzene, m-	541-73-1	Methyl Ethyl Ketone	78-93-3	Vinylidiene Chloride	75-35-4
Dichlorobenzene, o-	95-50-1	Methyl Methacrylate	80-62-6	Xylenes	1330-20-7
Dichlorobenzene, p-	106-46-7				

CAS # = Chemical Abstracts Service Registry Number.
DPGME = Dipropylene glycol monomethyl ether.
ETO = Ethylene oxide.
MIBK = Methyl isobutyl ketone (Hexone).
PGME = Propylene glycol monomethyl ether.
PGMEA = Propylene glycol monomethyl ether acetate.
SF6 = Sulfur Hexafluoride.
R-12 = Dichlorodifluoromethane.
R-13B = Bromotrifluoromethane.
R-14 = Carbon Tetrafluoride.
R-21 = Dichloromonofluoromethane.
R-22 = Chlorodifluoromethane.
R-23 = Trifluoromethane.
R-113 = 1,1,2-Trichloro-1,2,2-trifluoroethane.
R-114 = 1,2-Dichlorotetrafluoroethane.
R-124 = 2-Chloro-1,1,1,2-tetrafluoroethane.
R-125 = Pentafluoroethane.
R-134A = 1,1,1,2-Tetrafluoroethane.
R-142B = 1-chloro-1,1-difluoroethane.
R-143A = 1,1,1-Trifluoroethane.
R-152A = 1,1-Difluoroethane.
R-236FA = 1,1,1,3,3,3-Hexafluoropropane.

Compounds with an HQI of less than 70 percent are unlikely to be present in the sample. Conversely, compounds with an HQI greater than 70 percent are likely to be present in the sample, and use of the MIRAN SapphIRe in single-compound mode is appropriate. In single-compound mode, the MIRAN analyzer can be used to scan for individual compounds (one compound in each run). Single-compound mode provides the concentration of a specific organic compound present in the soil-vapor sample. The single-compound mode uses the same technology as the spectrum scan, but only looks at the specific absorption characteristics for a particular compound. The result of the single-compound mode yields a more accurate vapor concentration than the estimated concentration generated by the ThermoMatch software, although potential cross-interference with other compounds may affect the results.

During sampling activities, the weather was partly cloudy with a steady breeze coming out of the northwest. The temperature was about 70°F. During sampling, no detectable air movement either into or out of the wells occurred. This suggests no vapor dilution in the screened intervals by influx of atmospheric air.

Installation of the packer in well 299-E25-4 took place at approximately 9:15 a.m. During installation of sample tubing (installed during the packer descent) at this first well, the packer was stopped every 15.2 m (50 ft) to allow an additional length of sample tubing to be connected. Five sections of Teflon[3] lined TYGON[4] tubing were connected to a 3 m (10-ft) section attached to the packer to yield approximately 79.2 m (260 ft) of sample tubing.

The packer was set at 71.0 m (233 ft), a sample pump was installed on the sample tubing, and sample line purging commenced at 10:00 a.m.. The initial pumping rate was set at approximately 5 L/min, but was decreased to approximately 1.5 L/min as a result of the pump ceasing operation because of a flow-fault condition. The flow-fault condition frequently occurs when 0.6 cm (¼ in.) interior diameter TYGON tubing with a Teflon liner is used. The liner loses cohesion with the TYGON tube and collapses under the vacuum generated by the pump. This collapse seals the line and may not allow sufficient flow volume through the pump for proper operation. Without adequate flow, the pump shuts down and indicates a flow fault. To correct the condition, the pumping rate must be decreased and/or a larger interior-diameter TYGON tubing must be used.

During sample purging, the industrial hygiene technician conducted health and safety monitoring using a photoionization detector (PID) at the exhaust end of the sample pump. The pump was operated for approximately 10 minutes with the discharge open to the atmosphere to purge the system. The purge time took into consideration the purge volume of the sample line (approximately 0.6 L) and the volume of the well casing between the bottom of the packer and the water table (approximately 15 L). The depth to water used for this purpose was from recently completed borehole logging. The exhaust line was connected to the input wand of the MIRAN SapphIRe after purging and sampling commenced.

The ThermoMatch software produced an HQI of 18.5 percent, which falls into the poor hit-quality category and indicates that no organic compounds in the software library are present. Because the HQI was less than 70 percent, the analyzer was not reconfigured to analyze for a single compound.

A duplicate sample from well 299-E25-4 was analyzed after the analysis of the primary sample. The ThermoMatch software produced an HQI of 21.3 percent, which falls into the poor hit-quality category and indicates that no organic compounds in the software library are present in the duplicate sample. Because the HQI was less than 70 percent, the analyzer was not reconfigured to analyze for a single compound.

At the end of the sampling event, the sampling pump was switched off, the TYGON tubing was removed from the pump inlet, and the packer was removed from the well. While the packer was being removed from the well, the radiological control technician conducted radiological field screening of the sample tubing, packer inflation hose, and tape measure attached to the packer

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[3] Teflon is a trademark of E.I. du Pont de Nemours and Company, Wilmington, Delaware.

[4] TYGON is a registered trademark of Norton Performance Plastics Corporation, a Saint-Gobain Company, Akron, Ohio.

for depth determinations. All of the lines coming out of the well showed a coating of red dust, most likely reflecting rust from the inside of the casing. This red dust was present at all wells sampled.

During the sample tube extraction, coiling of the TYGON tubing into loops facilitated redeployment in the remaining wells. During coiling, running the tubing through a gloved hand removed a majority of the red dust. Survey of this material by the radiological control technician showed background levels for the area. Survey of the inflation hose and tape measure also showed background levels.

After the packer was removed from the well, the pump-setting rig was moved to the next well. After removing the wellhead cover at the next well, 299-E25-5, the industrial hygiene technician monitored the well head using the PID and detected no measurable vapor concentrations. The packer was set at a depth of 70.1 m (230 ft), and purging commenced at 11:10 a.m.. Sample analysis using the MIRAN SapphIRe occurred at approximately 11:20 a.m.. The resulting data file showed an HQI of 39.7 percent, indicating that no organic compounds were present. Based on the low HQI, the instrument was not reconfigured for single compound detection. The packer was removed from the well using the same process described above, and the pump-setting rig was moved to the next well. Radiological field screening indicated that all of the materials removed from the well were at background levels.

The next well sampled was 299-E25-7. The industrial hygiene technician detected no measurable organic vapor concentrations upon opening the wellhead, and the packer was set at a depth of 70.1 m (230 ft) at 12:00 p.m.. After purging, the sample was analyzed using the MIRAN SapphIRe. The ThermoMatch software yielded an HQI of 45.3 percent, indicating that no organic compounds were present. Based on the low HQI, the MIRAN SapphIRe was not reconfigured for single-compound detection. The sample pump was disconnected, and the packer was removed from the hole. Radiological field screening indicated that all of the materials removed from the well were at background levels.

The next well sampled was 299-E25-8. Upon removal of the wellhead cover, the PID detected transient values of 1 ppm. Because the readings on the PID decayed to zero after less than 3 seconds, it was determined that work could proceed safely. The packer was set at a depth of 72.8 m (239 ft) at 12:35 p.m.. After purging, analysis with the MIRAN SapphIRe resulted in an HQI of 46.0 percent. The low HQI indicated that no organic compounds were present, and the MIRAN SapphIRe was not reconfigured for single-compound detection. The packer was removed from the well, and the pump-setting rig was moved to the next well. Radiological field screening indicated that all of the materials removed from the well were at background levels.

The next well sampled was 299-E25-9. The industrial hygiene technician detected no measurable organic vapor concentrations using the PID upon removal of the wellhead cover. The packer was set at a depth of 69.5 m (228 ft) at 1:30 p.m.. After purging, sample analysis using the MIRAN SapphIRe resulted in an HQI of 53.1 percent. The low HQI indicated that no organic compounds were present, and the MIRAN SapphIRe was not reconfigured for single-compound detection. The packer was removed from the well.

During the extraction of the packer, a cloth was used to clean the dust from the sampling line. This cloth, when monitored by the radiological control technician, showed radiological activity above background levels. When the cloth was rechecked after a couple of minutes, the readings showed background levels, and it was determined by the radiological control technician that the elevated readings were from radon particles.

Based on the analytical data, no organic vapor concentrations were detected in samples collected from the screened intervals of these five wells.

A summary of these well data is presented in Table B-2.

Table B-2. Vapor Sample Summary for 216-A-8 Existing Wells.

Well ID	Sample Date / Time	Depth to Packer (ft below TOC)	IHT PID	RCT	HQI
299-E25-4	04/21/05 10:10	233	ND	Background	18.5 %
299-E25-4 duplicate	04/21/05 10:32	233	ND	Background	21.3 %
299-E25-5	04/21/05 11:20	230	ND	Background	39.7 %
299-E25-7	04/21/05 12:10	230	ND	Background	45.3 %
299-E25-8	04/21/05 12:45	239	Transient/ND	Background	46.0 %
299-E25-9	04/21/05 13:40	228	ND	Background	53.1 %

HQI = Hit Quality Index.
ID = identification number.
IHT PID = industrial health technician photoionization detector.
ND = non-detect.
RCT = radiological control technician.
TOC = top of casing.

Before the primary and duplicate samples from well 299-E25-4 were analyzed, a blank sample consisting of ambient air was analyzed on 04/21/05 at 9:26. The ThermoMatch software produced an HQI of 14.7 percent, indicating that no organic compounds in the software library are present in the blank. Because the HQI was less than 70 percent, the analyzer was not reconfigured to analyze for a single compound.

The MIRAN analyzer contains factory calibration data for 120 chemical compounds. The calibration data have been confirmed on site using calibration gases for the following eight volatile organic compounds: carbon tetrachloride, chloroform, methylene chloride, 1,1,1-trichloroethane (1,1,1-TCA), 1,1,2-trichloroethane (1,1,2-TCA), 1,1-dichloroethane (1,1-DCA), trichloroethylene (TCE), and tetrachloroethylene (PCE). Additionally, on a quarterly basis, the MIRAN analyzer is checked for instrument response using a closed-loop injection system and 10 certified chemical compounds. Results of the instrument response checks indicate that all 10 of these compounds show good response (Table B-3). Good agreement between the expected concentration and the instrument response indicates that the data generated from these analyses are reliable.

Calibration is conducted following each day of field screening analysis for those compounds that were detected during field screening of the samples. Because no organic compounds were detected during field screening of samples from these boreholes, no calibration was conducted following the field screening analyses.

Table B-3. Field-Screening Results for Calibration Standards.

Analysis Type	Analysis Date	MIRAN SapphIRe Ambient Air Analyzer									
		DCM (ppmv)	1,1-DCA (ppmv)	TCM (ppmv)	1,1,1-TCA (ppmv)	CCl_4 (ppmv)	TCE (ppmv)	1,1,2-TCA (ppmv)	PCE (ppmv)	Methane (ppmv)	CO_2 (ppmv)
Calibration Standard	NA	1.0	1.4	1.37	4.4	0.57	4	0.59	0.53	51	105.1
Calibration Check	03/10/05	1.2	1.6	1.47	4.6	0.60	5	0.64	0.45	63	110
% Recovery	NA	120	114	107	105	105	125	109	85	124	105

DCA = dichloroethane.
DCM = dichloromethane.
NA = not applicable.
PCE = tetrachloroethylene.
ppmv = parts per million by volume.
TCA = trichloroethane.
TCE = trichloroethylene.
TCM = trichloromethane (chloroform).

REFERENCE

DOE/RL-2001-01, 2004, *Plutonium/Organic-Rich Process Condensate/Process Waste Group Operable Unit RI/FS Work Plan, Includes: 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

APPENDIX C

GEOPHYSICAL LOGS FOR SIX EXISTING 216-A-8 WELLS

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APPENDIX C

GEOPHYSICAL LOGS FOR SIX EXISTING 216-A-8 WELLS

Hanford Office

DOE-EM/GJ653-2004

299-E25-4 (A4788)
Log Data Report

Borehole Information:

Borehole:	299-E25-4 (A4788)		Site:	216-A-8 Crib	
Coordinates (WA State Plane)		GWL (ft)[1]:	Not deep enough	GWL Date:	4/05/2004
North	East	Drill Date	TOC[2] Elevation	Total Depth (ft)	Type
136,169.12 m	575,648.83 m	April 1956	202.722 m	291	Cable Tool

Casing Information:

Casing Type	Stickup (ft)	Outer Diameter (in.)	Inside Diameter (in.)	Thickness (in.)	Top (ft)	Bottom (ft)
Welded steel	+2.20	6 5/8	6	5/16	+2.20	233
Welded steel	0	8	unknown	unknown		289

The logging engineer measured the casing stickup using a steel tape. A caliper was used to determine the outside casing diameter. The caliper and inside casing diameter were measured using a steel tape. Measurements were rounded to the nearest 1/16 in. Casing thickness was calculated. There is no evidence of 8-in. casing at the ground surface as reported in Ledgerwood (1993).

Borehole Notes:

Borehole coordinates, elevation, and well construction information are from measurements by Stoller field personnel, HWIS[3], and Ledgerwood (1993). Zero reference is the top of the 6-in. casing.

Logging Equipment Information:

Logging System:	Gamma 1G		Type:	35% HPGe (34TP10967A)
Calibration Date:	01/2004	Calibration Reference:	GJO-2004-597-TAC	
		Logging Procedure:	MAC-HGLP 1.6.5, Rev. 0	

Spectral Gamma Logging System (SGLS) Log Run Information:

Log Run	1	2	3	4 / Repeat	
Date	4/05/03	4/05/03	4/05/03	4/05/03	
Logging Engineer	Spatz	Spatz	Spatz	Spatz	
Start Depth (ft)	70.0	265.0	171.0	35.0	
Finish Depth (ft)	3.0	170.0	69.0	8.0	
Count Time (sec)	200	200	200	200	
Live/Real	R	R	R	R	
Shield (Y/N)	N	N	N	N	
MSA Interval (ft)	1.0	1.0	1.0	1.0	
ft/min	N/A[4]	N/A	N/A	N/A	
Pre-Verification	AG063CAB	AG064CAB	AG065CAB	AG066CAB	

Log Run	1	2	3	4 / Repeat	
Start File	AG063000	AG064000	AG065000	AG066000	
Finish File	AG063067	AG064095	AG065102	AG066027	
Post-Verification	AG063CAA	AG064CAA	AG065CAA	AG066CAA	
Depth Return Error (in.)	-1	0	-1	0	
Comments	No fine-gain adjustment.	Fine-gain adjustment after files -059 and -089.	Fine-gain adjustment after files -059 and -088.	Repeat section.	

Logging Operation Notes:

Zero reference was top of the 6-in. casing. Logging was performed without the centralizer on the sonde for spectral data collected between 265 and 170 ft. Pre- and post-survey verification measurements for the SGLS employed the Amersham KUT (^{40}K, ^{238}U, and ^{232}Th) verifier with serial number 118.

Analysis Notes:

Analyst:	Sobczyk	Date:	04/16/04	Reference:	GJO-HGLP 1.6.3, Rev. 0

SGLS pre-run and post-run verification spectra were collected at the beginning and end of each day. All of the post-run verification spectra were within the acceptance criteria. The peak counts per second (cps) at the 609-keV, 1461-keV, and 2615-keV photopeaks on the post-run verification spectra as compared to the pre-run verification spectra for each day were between 3.4 percent lower and 5.7 percent higher at the end of the day.

Log spectra for the SGLS were processed in batch mode using APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Post-run verification spectra were used to determine the energy and resolution calibration for processing the data using APTEC SUPERVISOR. Concentrations were calculated in EXCEL (source file: G1GJan04.xls), using parameters determined from analysis of recent calibration data. Zero reference was the top of the 6-in. casing. Based on Ledgerwood (1993), the casing configuration was assumed to be a string of 6-in. casing with a thickness of 5/16 in. to a log depth of 233 ft and a string of 8-in. casing with a thickness of 0.322 in. to total logging depth (265 ft). The 6-in. casing thickness was measured by the logging engineer. A casing thicknesss of 0.322 in. was assumed for the 8-in. casing. This thickness is the published value for ASTM schedule-40 steel pipe, a commonly used casing material at Hanford. Where more than one casing exists at a depth, the casing correction is additive (e.g., the correction for both 6-in. and 8-in. casing would be 0.313 + 0.322 = 0.635). A water correction was not required.

Log Plot Notes:

Separate log plots are provided for gross gamma and dead time, naturally occurring radionuclides (^{40}K, ^{238}U, and ^{232}Th), and man-made radionuclides. Plots of the repeat logs versus the original logs are included. In addition, a comparison log plot of ^{137}Cs is provided to compare the data collected in 1990 and 1995 by Westinghouse Hanford Company's Radionuclide Logging System (RLS) with SGLS data. For each radionuclide, the energy value of the spectral peak used for quantification is indicated. Unless otherwise noted, all radionuclides are plotted in picocuries per gram (pCi/g). The open circles indicate the minimum detectable level (MDL) for each radionuclide. Error bars on each plot represent error associated with counting statistics only and do not include errors associated with the inverse efficiency function, dead time correction, or casing correction. These errors are discussed in the calibration report. A combination plot is also included to facilitate correlation. The ^{214}Bi peak at 1764 keV was used to determine the naturally occurring ^{238}U concentrations on the combination plot rather than the ^{214}Bi peak at 609 keV because it exhibited slightly higher net counts per second.

Results and Interpretations:

^{137}Cs was the only man-made radionuclide detected in this borehole. ^{137}Cs was detected in two intervals. ^{137}Cs was detected from near the ground surface to a log depth of 30 ft. The range of concentrations was from the MDL (0.3 pCi/g) to 13.1 pCi/g; the maximum concentration was measured at 26 ft. ^{137}Cs was detected at log depths between 227 and 247 ft. The range of concentrations was from near the MDL to 1.4 pCi/g, which was measured at 233 ft. ^{137}Cs was also detected at 165 and 264 ft at concentrations near the MDL. The well construction summary (Ledgerwood 1993) shows 6-in. casing to 233 ft, with grout to 225 ft. The presence of grout in the annular space between the two casing strings is not accounted for, and likely contributes to underestimation of radionuclides above 225 ft. Spectral data below 225 ft are believed to more accurately represent the contaminated profile.

The concentrations of the KUT and man-made radionuclides above 225 ft are under estimated due to effects of grout. The total gamma increases by 50 cps, ^{40}K increases by 5 pCi/g and ^{232}Th increases by 0.3 pCi/g at 86 ft. The total gamma decreases by 40 cps and ^{40}K decreases by 5 pCi/g at 180 ft.

The plots of the repeat logs demonstrate reasonable repeatability of the SGLS data for the natural radionuclides (609, 1461, 1764, and 2614 keV) and ^{137}Cs.

Gross gamma logs from Additon et al. (1977) (attached) indicate that the sediments surrounding this borehole contained significant amounts of man-made gamma radiation from 1958 through at least 1976. The logs from 1958 and 1959 indicate high levels of gamma-emitting contamination at or near groundwater. The logs from 2/19/58 and 6/1/59 appear to detect relatively high gamma activity in the intervals from 6 ft (2 m) to 131 ft (40 m), 187 ft (57 m) to 197 ft (60 m), and below 233 ft (71 m). The log from 5/14/63 appears to detect relatively high gamma activity in the interval from 10 ft (3 m) to 131 ft (40 m). The log from 2/20/76 appears to detect relatively high gamma activity in the interval from 10 ft (3 m) to 26 ft (8 m). Comparison of these gross gamma logs indicates that a contamination event occurred prior 1958, which was followed by another event after 1959 and before 1963. The SGLS detected ^{137}Cs in only two of the intervals (3 to 30 ft and 227 to 247 ft), which had elevated gamma in the late 1950s. Man-made radionuclides were not detected in the interval from 187 to 197 ft with the SGLS.

A comparison log plot of ^{137}Cs data collected in 1990 and 1995 by Westinghouse Hanford Company (WHC) and in 2004 by Stoller is included. The WHC concentration data for ^{137}Cs are decayed to the date of the SGLS logging event in April 2004. No data were collected below 120 ft in the 1990 RLS log run. The SGLS and 1990 RLS log appear to use a slightly different depth reference. Because both the 1990 and 1995 data are corrected for only one string of casing (0.33 in. and 0.26 in., respectively), the ^{137}Cs concentrations based on the SGLS data were recalculated for this comparison using a casing thickness of 0.26 in. Assuming a thinner casing yields lower concentration values. Taking into account the differences in depth registration, the modified ^{137}Cs concentrations show good agreement between the logging systems. Since 1990, ^{137}Cs activities have decreased as predicted by radioactive decay.

References:

Additon, M.K., K.R. Fecht, T.L. Jones, and G.V. Last, 1978. *Scintillation Probe Profiles From 200 East Area Crib Monitoring Wells*, RHO-LD-28, Rockwell Hanford Operations, Richland, Washington.

Ledgerwood, R.K., 1993. *Summaries of Well Construction Data and Field Observations for Existing 200-East Resource Protection Wells*, WHC-SD-ER-TI-007, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

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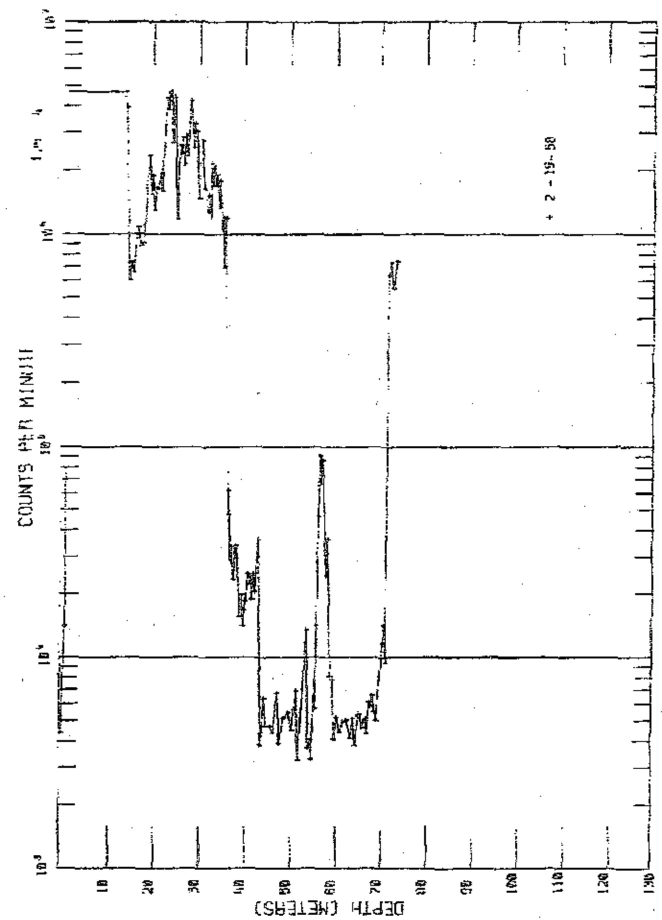
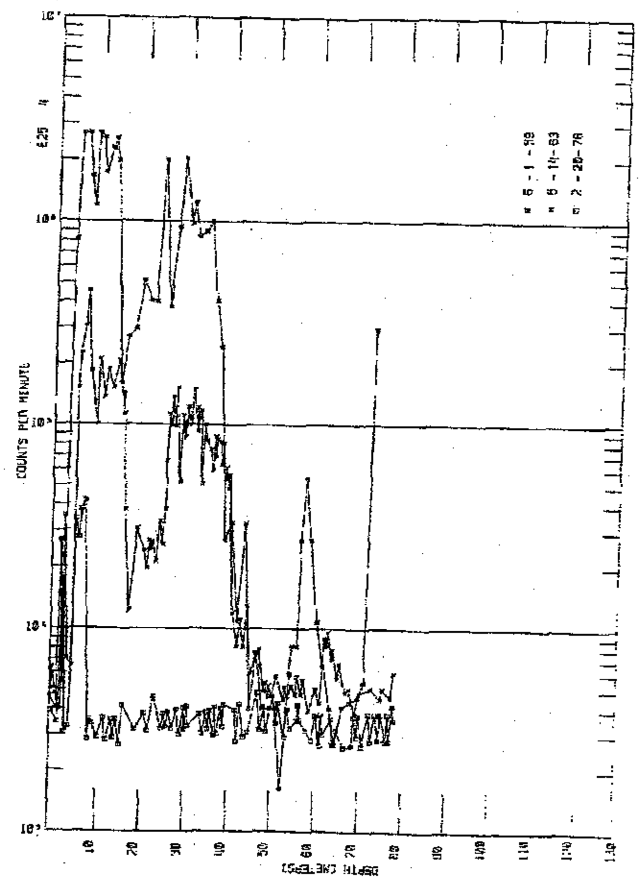
[1] GWL – groundwater level
[2] TOC – top of casing
[3] HWIS – Hanford Well Information System
[4] N/A – not applicable



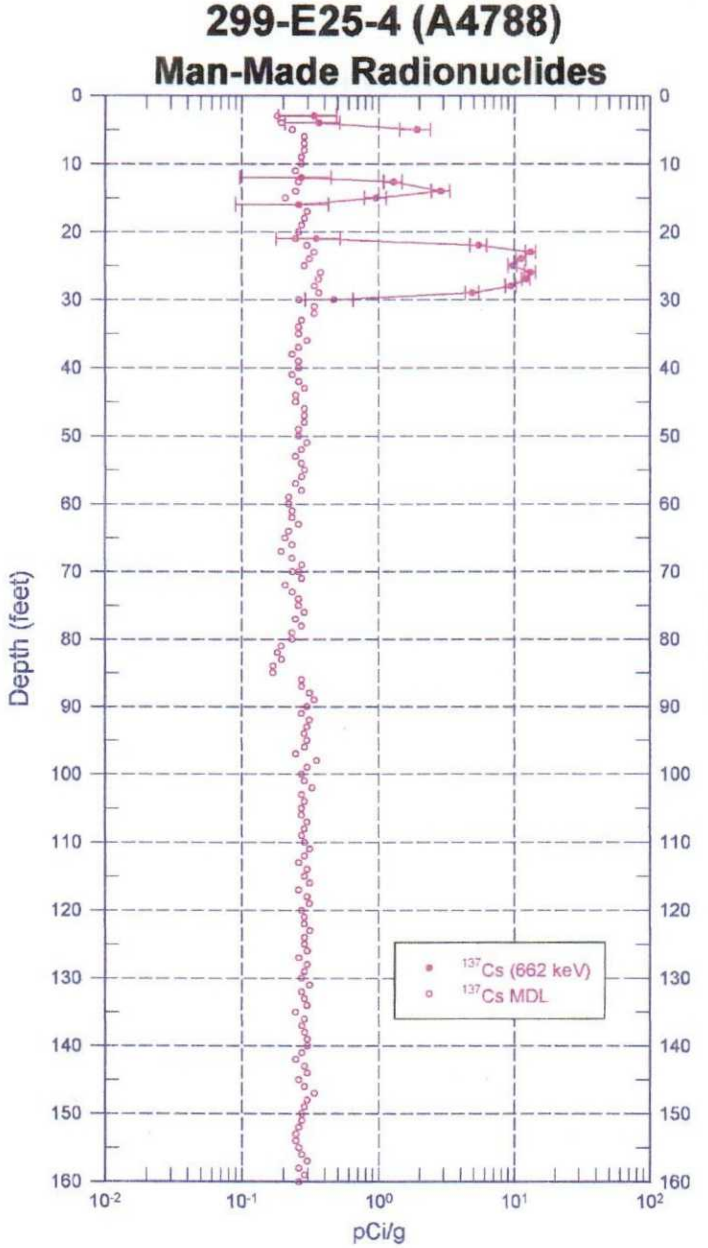
from Additon et al. (1978)

Scintillation Probe Profiles for Borehole 299-E25-4, Logged on 2/19/58



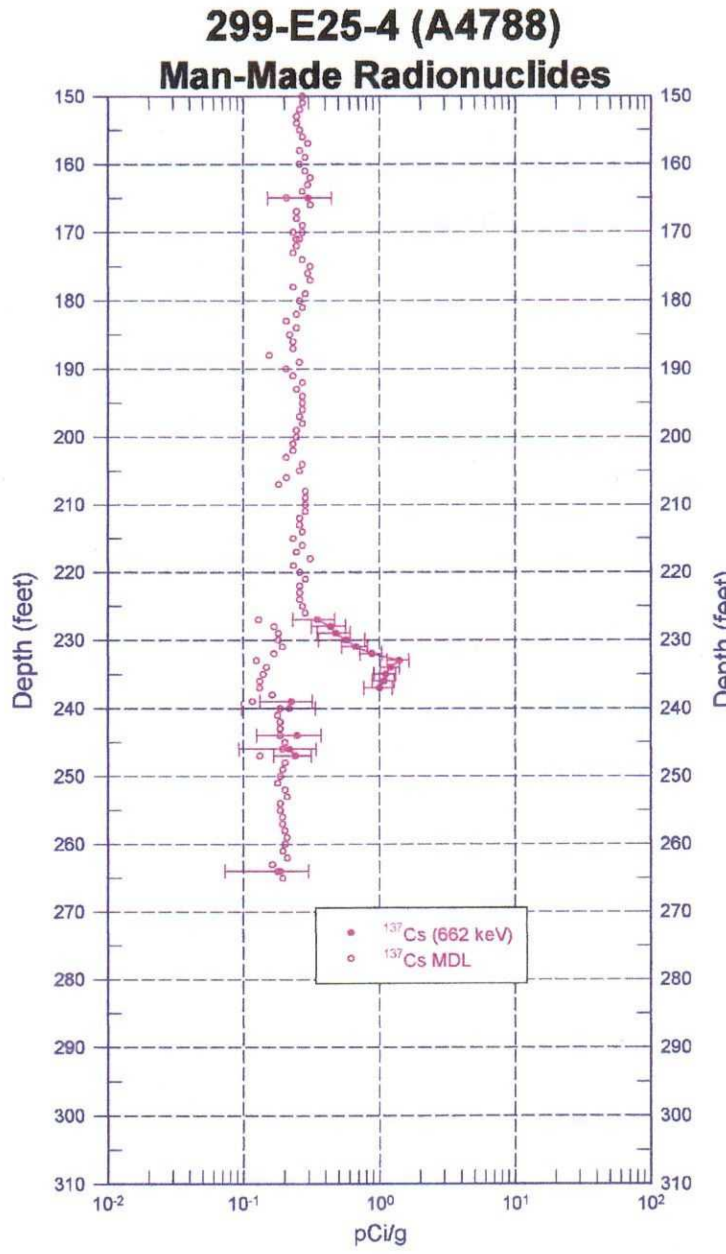
from Additon et al. (1978)

Scintillation Probe Profiles for Borehole 299-E25-4, Logged on 6/1/59, 5/14/63, and 2/20/76



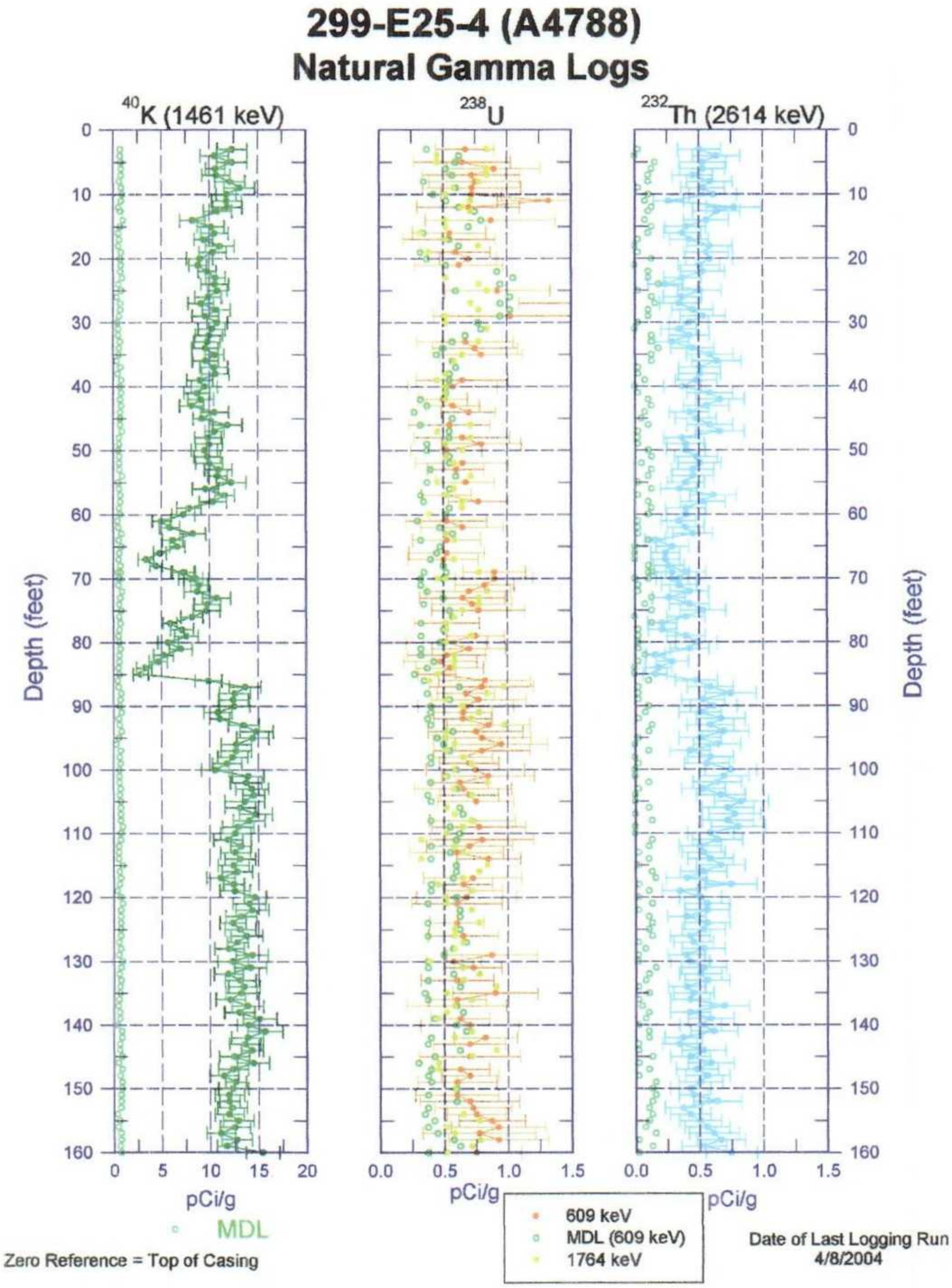
Zero Reference = Top of Casing

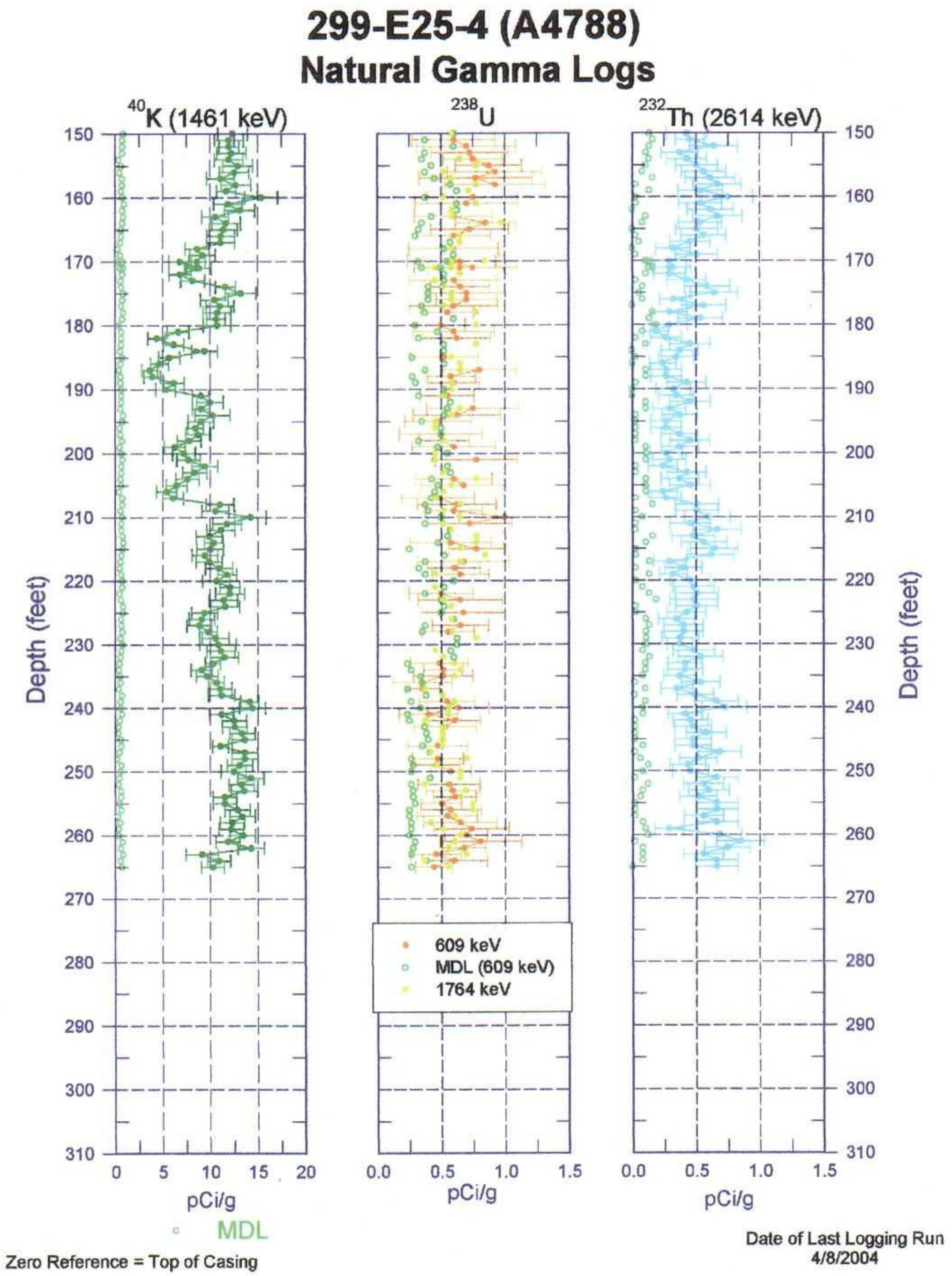
Date of Last Logging Run
4/08/2004

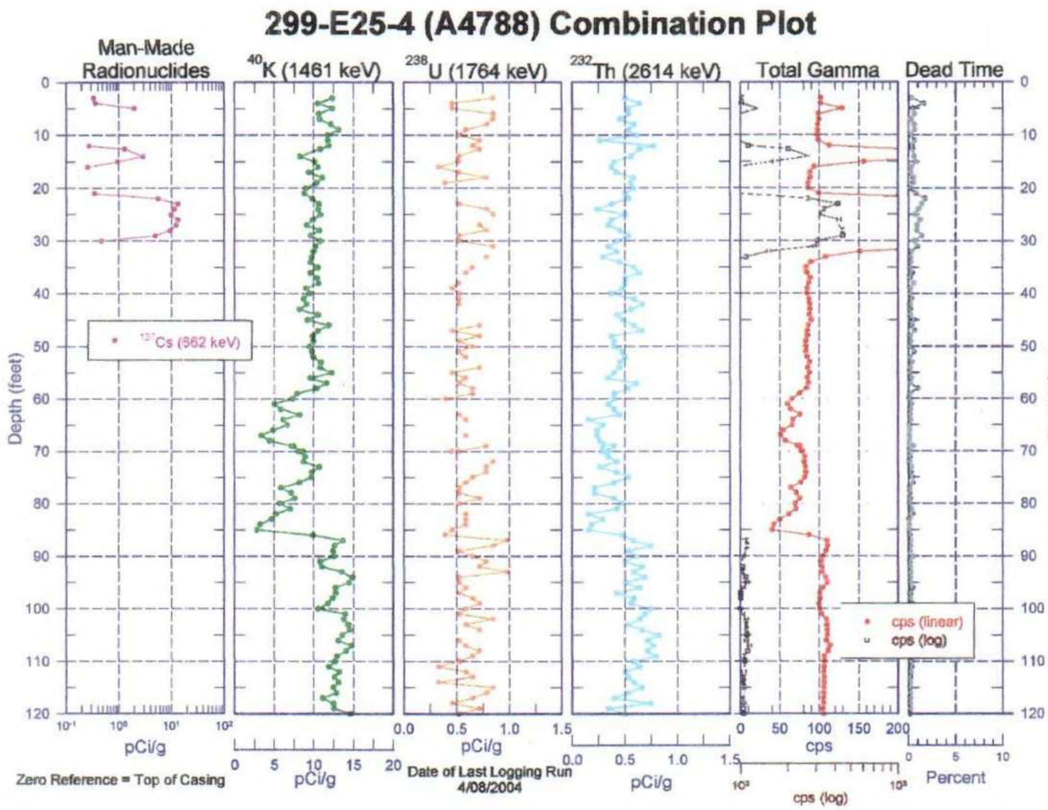


Zero Reference = Top of Casing

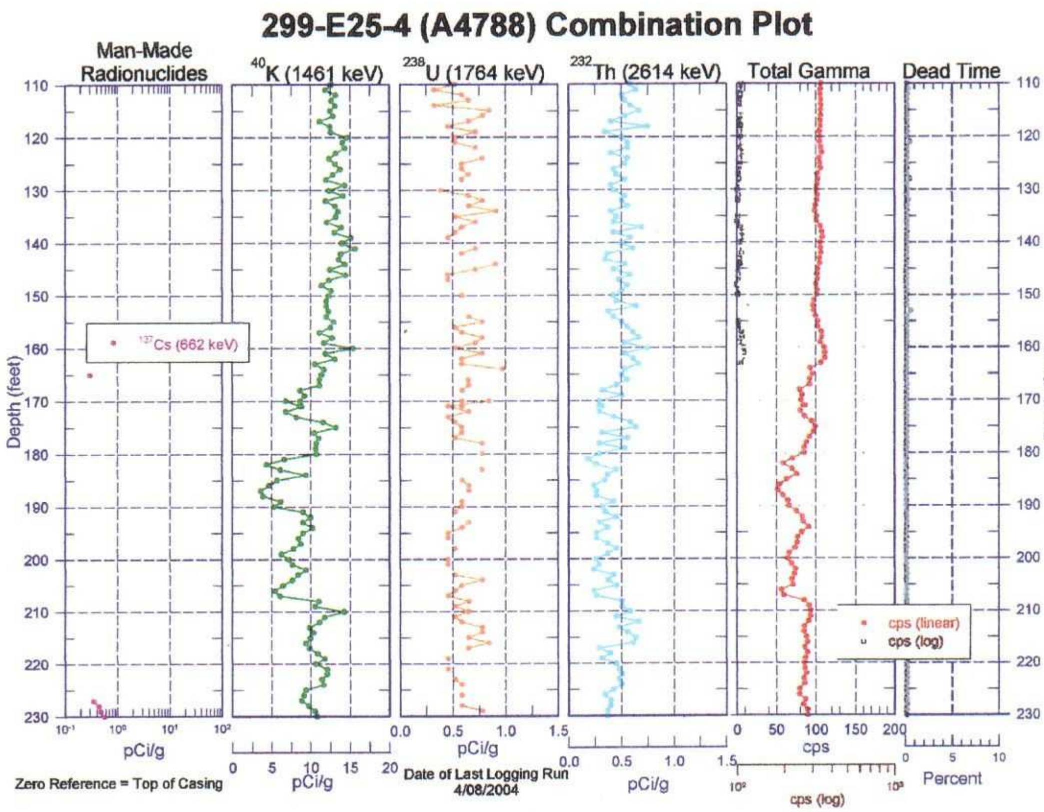
Date of Last Logging Run
4/08/2004

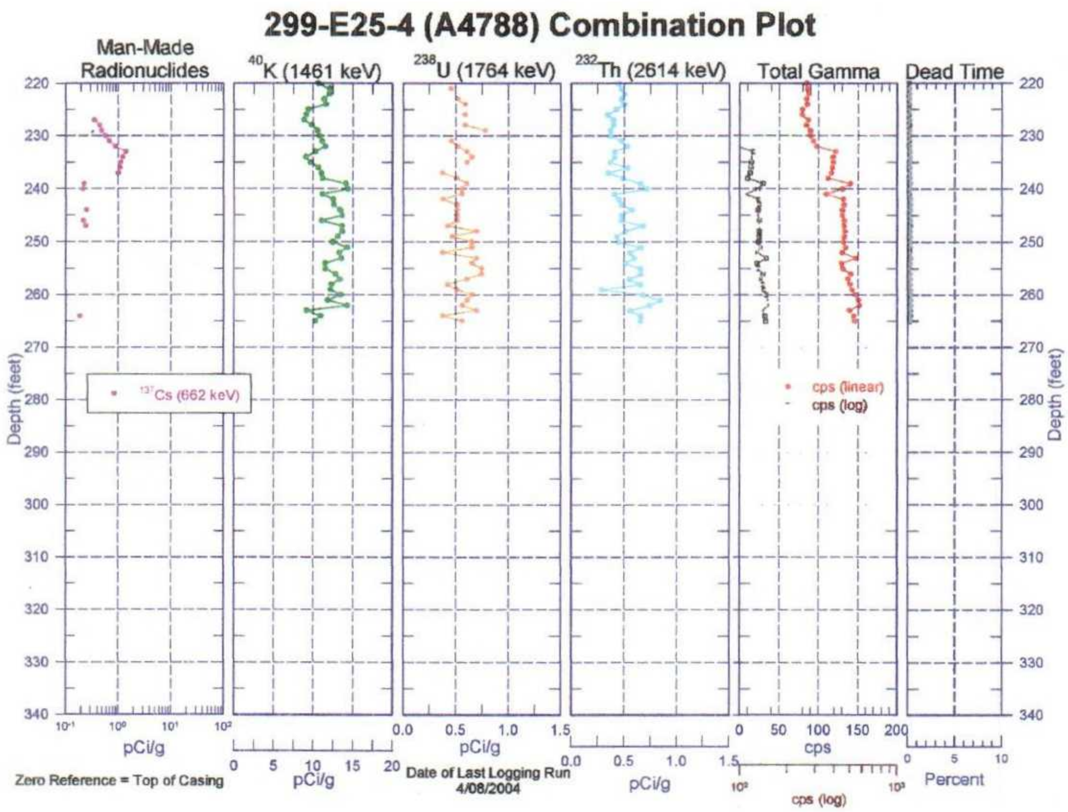

299-E25-4 (A4788)
Natural Gamma Logs
^{40}K (1461 keV)
^{238}U
^{232}Th (2614 keV)
Depth (feet)
pCi/g
MDL
Zero Reference = Top of Casing
609 keV
MDL (609 keV)
1764 keV
Date of Last Logging Run
4/8/2004


299-E25-4 (A4788)
Natural Gamma Logs
40K (1461 keV)
238U
232Th (2614 keV)
Depth (feet)
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
0 5 10 15 20
pCi/g
MDL
0.0 0.5 1.0 1.5
pCi/g
609 keV
MDL (609 keV)
1764 keV
0.0 0.5 1.0 1.5
pCi/g
Zero Reference = Top of Casing
Date of Last Logging Run
4/8/2004

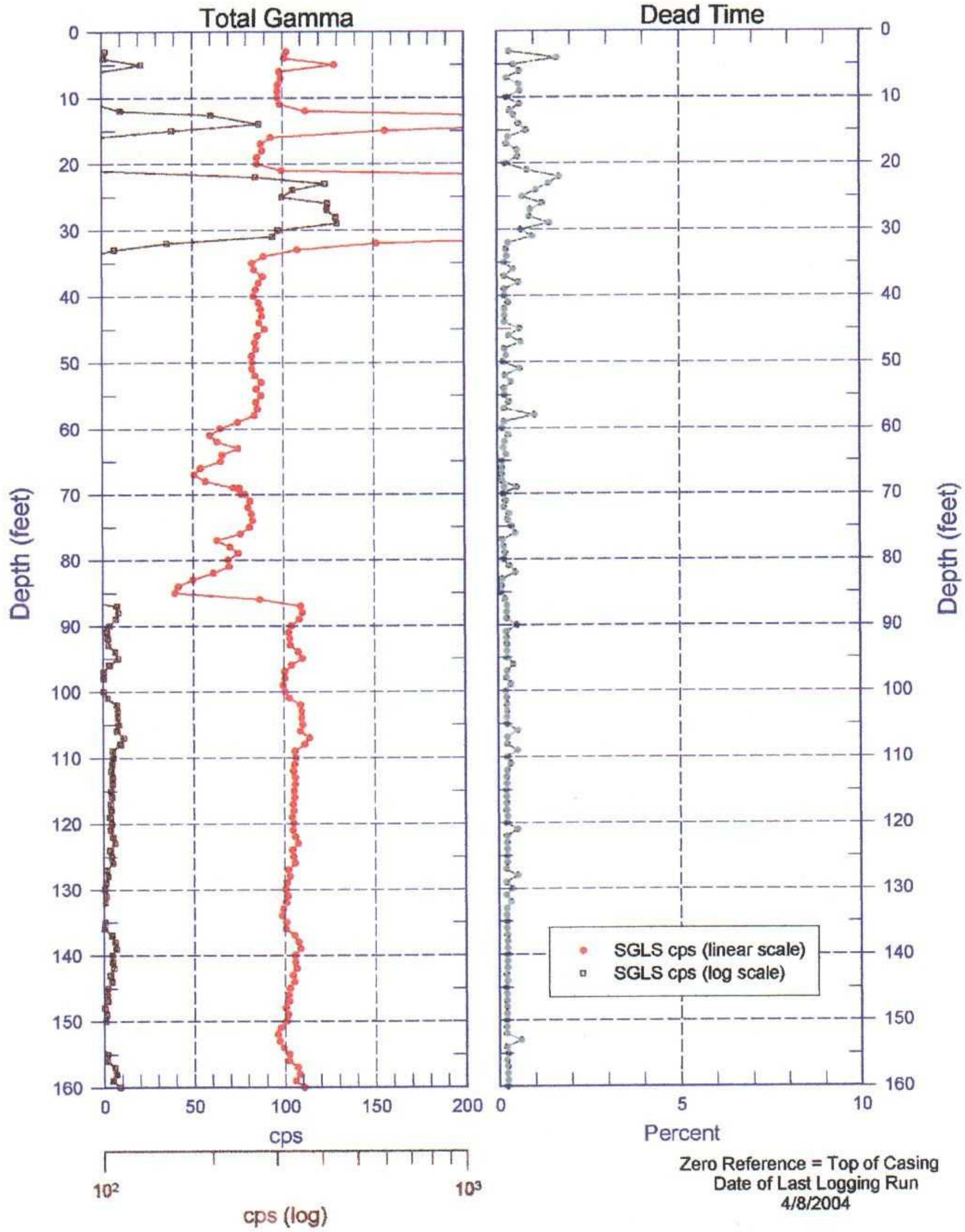


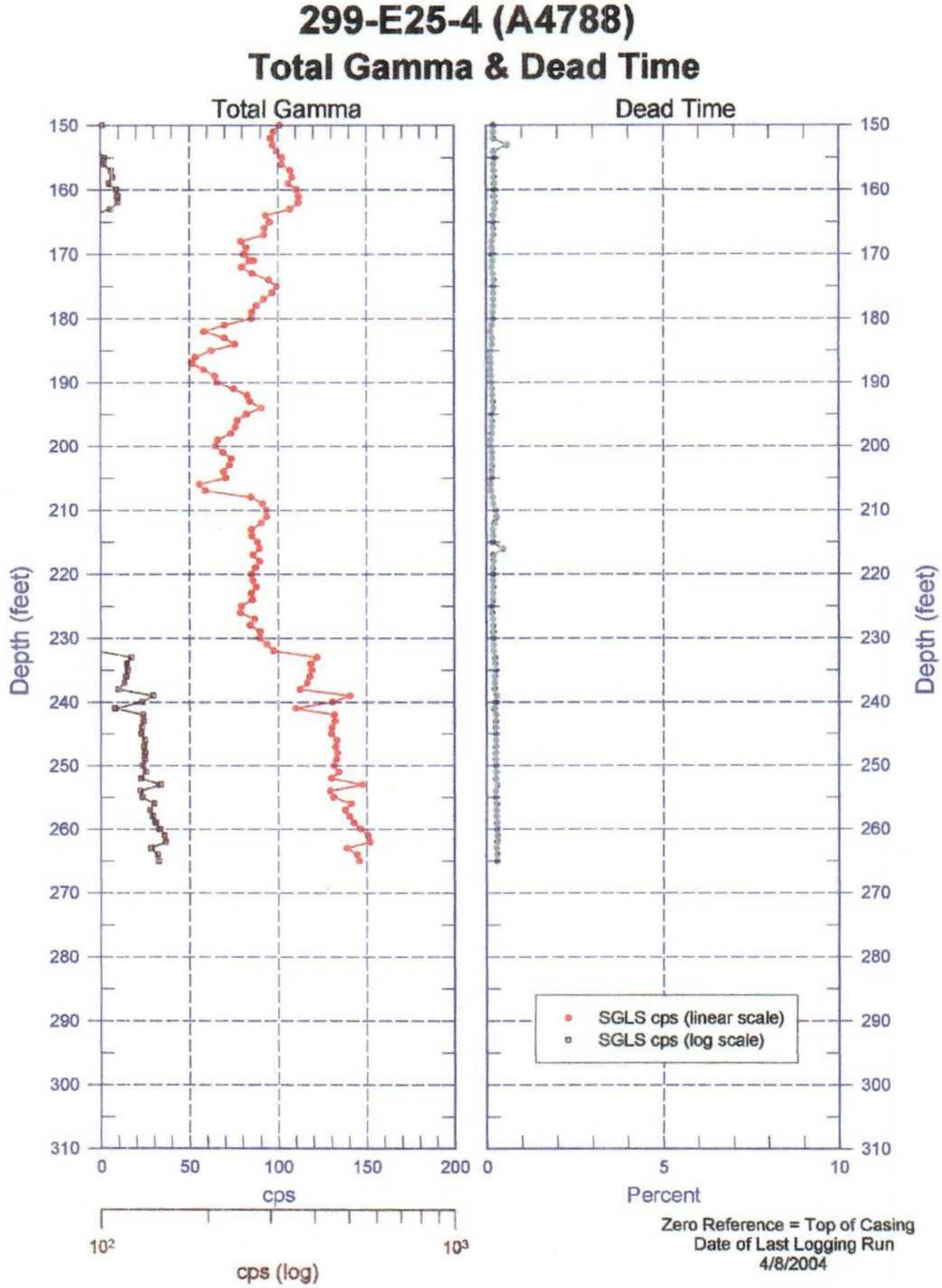
299-E25-4 (A4788) Combination Plot
Man-Made Radionuclides
⁴⁰K (1461 keV)
²³⁸U (1764 keV)
²³²Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
¹³⁷Cs (662 keV)
cps (linear)
cps (log)
pCi/g
cps
cps (log)
Percent
Zero Reference = Top of Casing
Date of Last Logging Run 4/08/2004

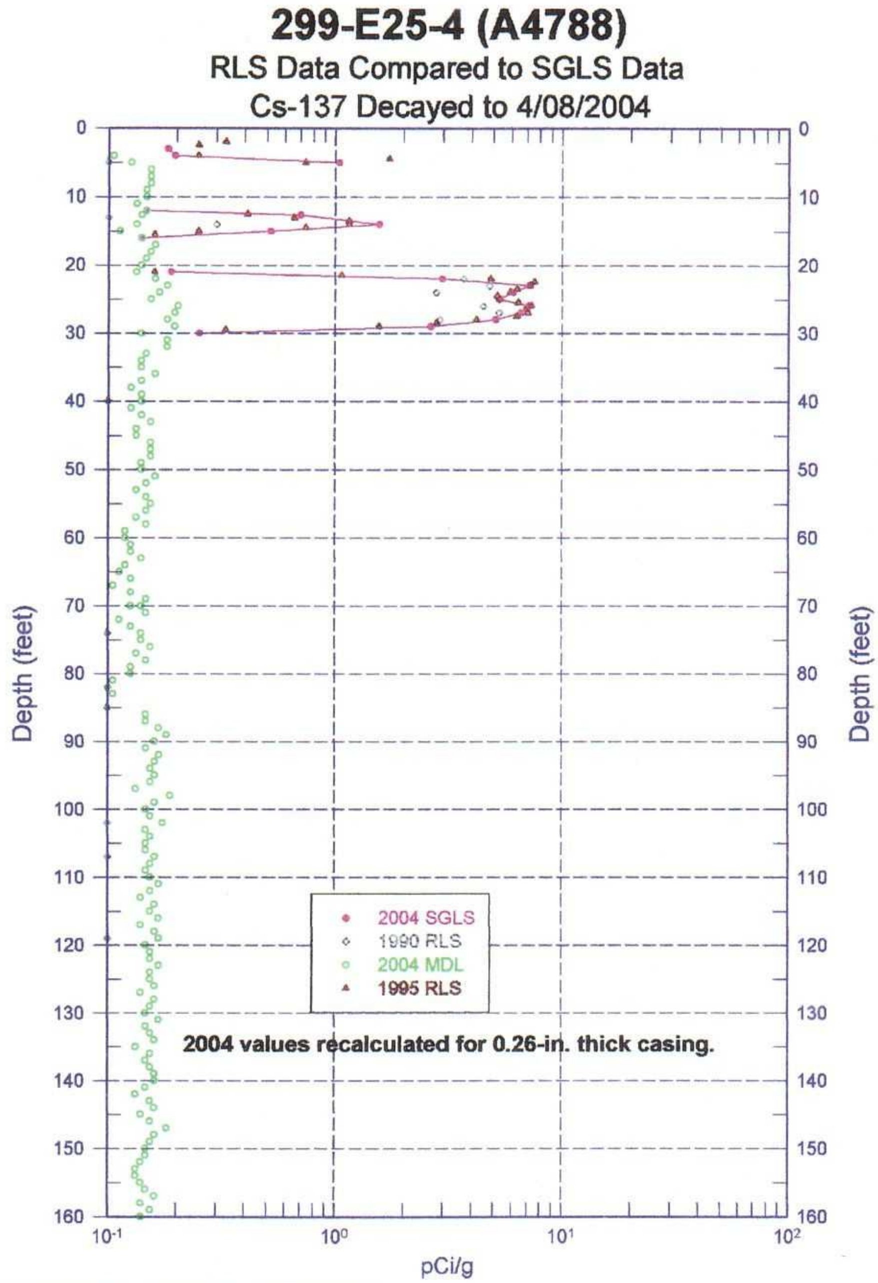

299-E25-4 (A4788) Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
137Cs (662 keV)
Depth (feet)
pCi/g
Zero Reference = Top of Casing
Date of Last Logging Run 4/08/2004
cps
cps (log)
cps (linear)
Percent


299-E25-4 (A4788) Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
137Cs (662 keV)
cps (linear)
cps (log)
pCi/g
cps
Percent
Zero Reference = Top of Casing
Date of Last Logging Run
4/08/2004

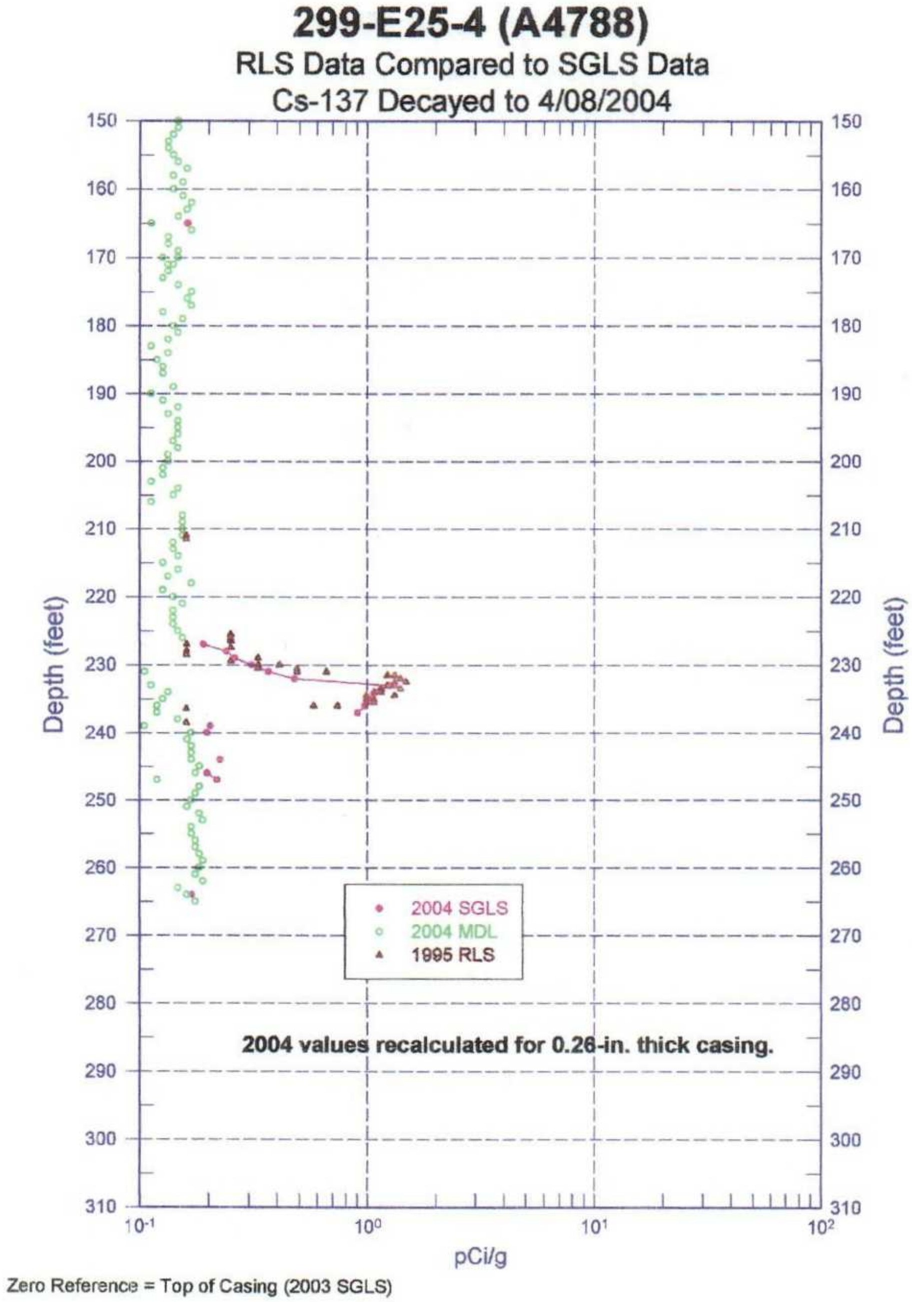
299-E25-4 (A4788)
Total Gamma & Dead Time




299-E25-4 (A4788)
Total Gamma & Dead Time
Total Gamma
Dead Time
Depth (feet)
cps
cps (log)
Percent
SGLS cps (linear scale)
SGLS cps (log scale)
Zero Reference = Top of Casing
Date of Last Logging Run
4/8/2004



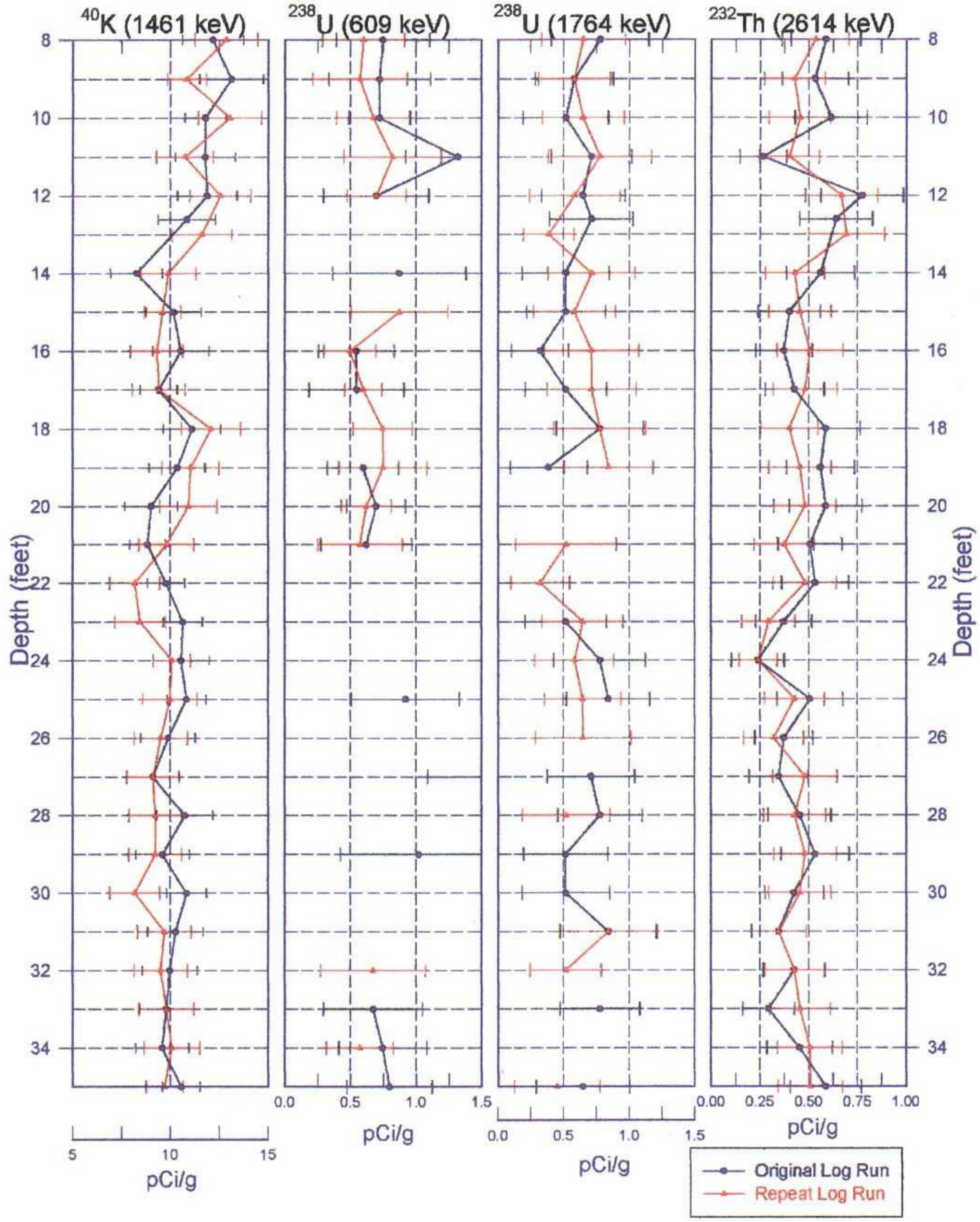
Zero Reference = Top of Casing (2003 SGLS)
1990 RLS shifted down 2.0 ft to align with the SGLS

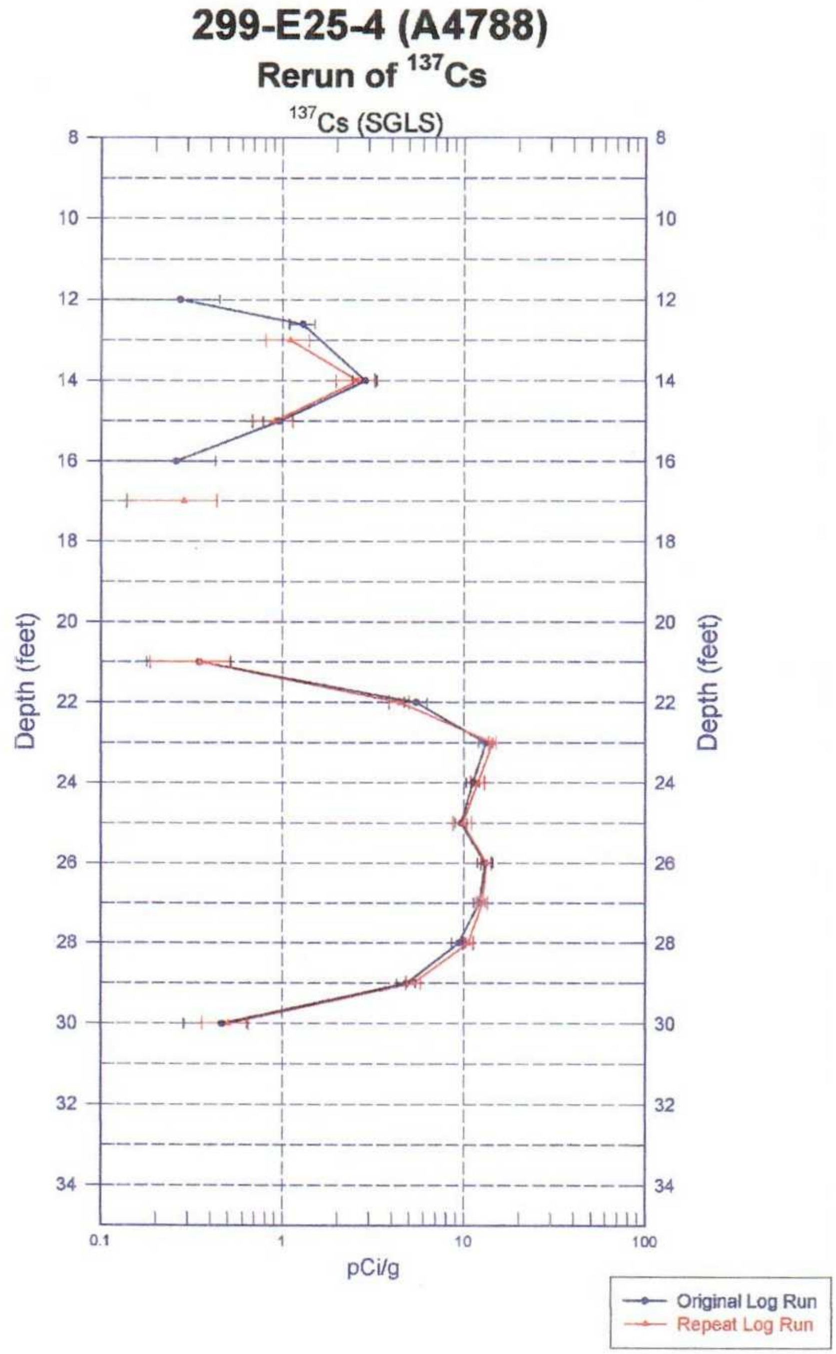


299-E25-4 (A4788)
RLS Data Compared to SGLS Data
Cs-137 Decayed to 4/08/2004
Depth (feet)
pCi/g
2004 SGLS
2004 MDL
1995 RLS
2004 values recalculated for 0.26-in. thick casing.
Zero Reference = Top of Casing (2003 SGLS)

299-E25-4 (A4788)

Rerun of Natural Gamma Logs (35.0 to 8.0 ft)





299-E25-4 (A4788)
Rerun of 137Cs
137Cs (SGLS)
Depth (feet)
pCi/g
0.1
1
10
100
8
10
12
14
16
18
20
22
24
26
28
30
32
34
Original Log Run
Repeat Log Run

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Hanford Office

DOE-EM/GJ655-2004

299-E25-5 (A6025)
Log Data Report

Borehole Information:

Borehole:	299-E25-5 (A6025)		Site:	216-A-8 Crib	
Coordinates (WA State Plane)		GWL (ft)[1]:	262.35	GWL Date:	4/12/2004
North	East	Drill Date	TOC[2] Elevation	Total Depth (ft)	Type
136,184.94 m	575,618.24 m	May 1956	202.231 m	293	Cable Tool

Casing Information:

Casing Type	Stickup (ft)	Outer Diameter (in.)	Inside Diameter (in.)	Thickness (in.)	Top (ft)	Bottom (ft)
Welded steel	+2.05	6 5/8	6 1/8	1/4	+2.05	230
Welded steel	0	8	unknown	unknown		293

The logging engineer measured the casing stickup using a steel tape. A caliper was used to determine the outside casing diameter. The caliper and inside casing diameter were measured using a steel tape. Measurements were rounded to the nearest 1/16 in. Casing thickness was calculated. There is no evidence of 8-in. casing at the ground surface as reported in Ledgerwood (1993).

Borehole Notes:

Borehole coordinates, elevation, and well construction information are from measurements by Stoller field personnel, HWIS[3], and Ledgerwood (1993). Zero reference is the top of the 6-in. casing.

Logging Equipment Information:

Logging System:	Gamma 1G		Type: 35% HPGe (34TP10967A)
Calibration Date:	01/2004	Calibration Reference:	GJO-2004-597-TAC
		Logging Procedure:	MAC-HGLP 1.6.5, Rev. 0

Logging System:	Gamma 1C		Type: High Rate Detector (39A314)
Calibration Date:	02/07/02	Calibration Reference:	GJO-2003-429-TAC
		Logging Procedure:	MAC-HGLP 1.6.5, Rev. 0

Spectral Gamma Logging System (SGLS) Log Run Information:

Log Run	1	2	3	4	5
Date	4/12/04	4/12/04	4/12/04	4/14/04	4/15/04
Logging Engineer	Spatz	Spatz	Spatz	Spatz	Spatz
Start Depth (ft)	97.0	32.0	21.0	261.0	164.0
Finish Depth (ft)	33.0	21.0	2.0	163.0	96.0
Count Time (sec)	200	20	200	200	200
Live/Real	R	R	R	R	R

Log Run	1	2	3	4	5
Shield (Y/N)	N	N	N	N	N
MSA Interval (ft)	1.0	1.0	1.0	1.0	1.0
ft/min	N/A[4]	N/A	N/A	N/A	N/A
Pre-Verification	AG067CAB	AG067CAB	AG067CAB	AG068CAB	AG069CAB
Start File	AG067000	AG067065	AG067077	AG068000	AG069000
Finish File	AG067064	AG067076	AG067096	AG068098	AG069068
Post-Verification	AG067CAA	AG067CAA	AG067CAA	AG068CAA	AG069CAA
Depth Return Error (in.)	N/A	N/A	+1	-1	N/A
Comments	No fine-gain adjustment.	High rate zone. Dead time > 40%. Count time change.	No fine-gain adjustment.	No fine-gain adjustment.	No fine-gain adjustment.

Log Run	6 / Repeat				
Date	4/15/04				
Logging Engineer	Spatz				
Start Depth (ft)	78.0				
Finish Depth (ft)	52.0				
Count Time (sec)	200				
Live/Real	R				
Shield (Y/N)	N/A				
MSA Interval (ft)	1.0				
ft/min	N/A				
Pre-Verification	AG069CAB				
Start File	AG069069				
Finish File	AG069095				
Post-Verification	AG069CAA				
Depth Return Error (in.)	-1				
Comments	Repeat section.				

High Rate Logging System (HRLS) Log Run Information:

Log Run	1	2	3	4 / Repeat	
Date	4/16/04	4/16/04	4/16/04	4/16/04	
Logging Engineer	Spatz	Spatz	Spatz	Spatz	
Start Depth (ft)	34.0	29.0	22.0	26.0	
Finish Depth (ft)	30.0	23.0	21.0	23.0	
Count Time (sec)	300	100	300	100	
Live/Real	R	R	R	R	
Shield (Y/N)	none	none	none	none	
MSA Interval (ft)	1.0	1.0	1.0	1.0	
ft/min	N/A	N/A	N/A	N/A	
Pre-Verification	AC098CAB	AC098CAB	AC098CAB	AC098CAB	
Start File	AC098000	AC098005	AC098012	AC098014	
Finish File	AC098004	AC098011	AC098013	AC098016	
Post-Verification	AC098CAA	AC098CAA	AC098CAA	AC098CAA	
Depth Return Error (in.)	N/A	N/A	N/A	0	

Log Run	1	2	3	4 / Repeat	
Comments	No fine-gain adjustment.	None	None	Repeat section.	

Logging Operation Notes:

Zero reference was top of the 6-in. casing. Logging was performed without the centralizer on the sonde for spectral data collected between 261 and 163 ft. Pre- and post-survey verification measurements for the SGLS employed the Amersham KUT (^{40}K, ^{238}U, and ^{232}Th) verifier with serial number 118. HRLS data were collected using Gamma 1C. Pre- and post-survey verification measurements employed the ^{137}Cs verifier with serial number 1013.

Analysis Notes:

Analyst:	Sobczyk	Date:	04/21/04	Reference:	GJO-HGLP 1.6.3, Rev. 0

SGLS pre-run and post-run verification spectra were collected at the beginning and end of each day. All of the post-run verification spectra were within the acceptance criteria. The peak counts per second (cps) at the 609-keV, 1461-keV, and 2615-keV photopeaks on the post-run verification spectra as compared to the pre-run verification spectra for each day were between 3.4 percent lower and 4.7 percent higher at the end of the day.

HRLS pre-run and post-run verification spectra were collected at the beginning and end of the day. The spectra were within the acceptance criteria for the field verification of the Gamma 1C logging system (HRLS).

Log spectra were processed in batch mode using APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Post-run verification spectra were used to determine the energy and resolution calibration for processing the data using APTEC SUPERVISOR. Concentrations were calculated in EXCEL (source files: G1GJan04.xls [SGLS] and G1CApr03.xls [HRLS]), using parameters determined from analysis of recent calibration data. Zero reference was the top of the 6-in. casing. Based on Ledgerwood (1993), the casing configuration was assumed to be a string of 6-in. casing with a thickness of 1/4 in. to a log depth of 232 ft and a string of 8-in. casing with a thickness of 0.322 in. to total logging depth (261 ft). The logging engineer measured the 6-in. casing thickness. A casing thickness of 0.322 in. was assumed for the 8-in. casing. This thickness is the published value for ASTM schedule-40 steel pipe, a commonly used casing material at Hanford. Where more than one casing exists at a depth, the casing correction is additive (e.g., the correction for both 6-in. and 8-in. casing would be 0.25 + 0.322 = 0.572). A water correction was not required.

Using the SGLS, dead time greater than 40 percent were encountered in the interval from 22 to 33 ft, and data from this region were considered unreliable. At SGLS dead time greater than 40 percent, peak spreading and pulse pile-up effects may result in underestimation of activities. This effect is not entirely corrected by the dead time correction, and the extent of error increases with increasing dead time. SGLS dead time corrections are applied when dead time is greater than 10 percent. The HRLS was utilized to obtain data where the SGLS dead time exceeded 40 percent.

Log Plot Notes:

Separate log plots are provided for gross gamma and dead time, naturally occurring radionuclides (^{40}K, ^{238}U, and ^{232}Th), and man-made radionuclides. Plots of the repeat logs versus the original logs are included. In addition, a comparison log plot of ^{137}Cs is provided to compare the data collected in 1990 and 1995 by Westinghouse Hanford Company's Radionuclide Logging System (RLS) with SGLS data. For each radionuclide, the energy value of the spectral peak used for quantification is indicated. Unless otherwise noted, all radionuclides are plotted in picocuries per gram (pCi/g). The open circles indicate the minimum detectable level (MDL) for each radionuclide. Error bars on each plot represent error associated with counting statistics only and do not include errors associated with the inverse efficiency function, dead time correction, or casing correction. These errors are discussed in the calibration report. A combination plot is also included to facilitate correlation. The ^{214}Bi peak at 1764 keV was used to determine the naturally occurring ^{238}U concentrations.

Results and Interpretations:

^{137}Cs was the only man-made radionuclide detected in this borehole. ^{137}Cs was detected in three intervals. ^{137}Cs was detected from near the ground surface to a log depth of 6 ft. The range of concentrations was from the MDL (0.3 pCi/g) to 12.8 pCi/g. ^{137}Cs was detected at log depths between 20 and 53 ft. The range of concentrations was from 0.4 to 30,800 pCi/g, which was measured at 25 ft. ^{137}Cs was detected at log depths between 232 and 259 ft. The range of concentrations was from near the MDL to 0.8 pCi/g, which was measured at 232 ft. ^{137}Cs was also detected at 207 and 221 ft at concentrations near the MDL. The well construction summary (Ledgerwood 1993) reported 6-in. casing to 232 ft, with grout to 232 ft. The presence of grout in the annular space between the two casing strings is not accounted for, and likely contributes to underestimation of radionuclides above 232 ft. Spectral data below 232 ft are believed to more accurately represent the contaminated profile.

The concentrations of the KUT and man-made radionuclides above 232 ft are under estimated due to effects of grout.

The behavior of the ^{238}U log suggests that radon may be present inside the borehole casing. Determination of ^{238}U is based on measurement of gamma activity at 609 and/or 1764 keV associated with ^{214}Bi, under the assumption of secular equilibrium in the decay chain. However, ^{214}Bi is also a short-term daughter of ^{222}Rn. When radon is present, ^{214}Bi will tend to "plate" onto the casing wall and will quickly reach equilibrium with ^{222}Rn. Because the additional ^{214}Bi resulting from radon is on the inside of the casing, the effect of the casing correction is to amplify the 609 photopeak relative to the 1764 photopeak. (The magnitude of the casing correction factor decreases with increasing energy, but gamma rays originating inside the casing are not attenuated.) This effect is observed on 4/12/04 (97 to 2 ft). The effects of radon appear to be minimal in log runs 5 (164 to 96 ft) and 6 (78 to 52 ft). The reason for variations in radon content between log runs on successive days is not known. Variations in radon content in boreholes are probably related to variations in surface weather conditions. Radon daughters such as ^{214}Bi may also "plate" onto the sonde itself. When this occurs, there is a gradual increase in total counts as well as photopeak counts associated with ^{214}Bi and ^{214}Pb.

The presence of radon is not an indication of man-made contamination: it is derived from decay of naturally occurring uranium. As a gas, radon moves easily in the subsurface, and concentrations of radon and its associated progeny can change quickly.

The plots of the repeat logs demonstrate reasonable repeatability of the SGLS data for the natural radionuclides (1461, 1764, and 2614 keV), and ^{137}Cs for both the SGLS and HRLS.

Gross gamma logs from Additon et al. (1977) (attached) indicate that the sediments surrounding this borehole contained significant amounts of man-made gamma radiation from 1958 through at least 1976. The logs from 1958, 1959, and 1963 indicate gamma-emitting contamination at or near groundwater. The log from 2/19/58 appears to detect relatively high gamma activity in the intervals from 13 ft (4 m) to total depth. The log from 5/14/63 appears to detect relatively high gamma activity in the interval from 16 ft (5 m) to 128 ft (39 m). The log from 4/30/76 appears to detect relatively high gamma activity in the interval from 16 ft (5 m) to 39 ft (12 m). Comparison of these gross gamma logs indicates that a contamination event occurred prior to 1958. The SGLS detected ^{137}Cs in only two intervals (20 to 53 ft and 232 to 259 ft), while the entire length of the borehole below 16 ft had elevated gamma in the late 1950s.

A comparison log plot of ^{137}Cs data collected in 1990 and 1995 by Westinghouse Hanford Company (WHC) and in 2004 by Stoller is included. The WHC concentration data for ^{137}Cs are decayed to the date of the SGLS logging event in April 2004. Because both the 1990 and 1995 data corrected for only one string of casing (0.33 in. and 0.26 in., respectively), the ^{137}Cs concentrations based on the SGLS data were recalculated for this comparison using a casing thickness of 0.33 in. The apparent ^{137}Cs concentrations show good agreement between the logging systems above 230 ft. Since 1990, ^{137}Cs activities have decreased as predicted by radioactive decay in the interval above 230 ft. Data suggest an incursion of ^{137}Cs between 1990 and 1995 in the interval from 230 to 260 ft.

References:

Additon, M.K., K.R. Fecht, T.L. Jones, and G.V. Last, 1978. *Scintillation Probe Profiles From 200 East Area Crib Monitoring Wells*, RHO-LD-28, Rockwell Hanford Operations, Richland, Washington.

Ledgerwood, R.K., 1993. *Summaries of Well Construction Data and Field Observations for Existing 200-East Resource Protection Wells*, WHC-SD-ER-TI-007, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

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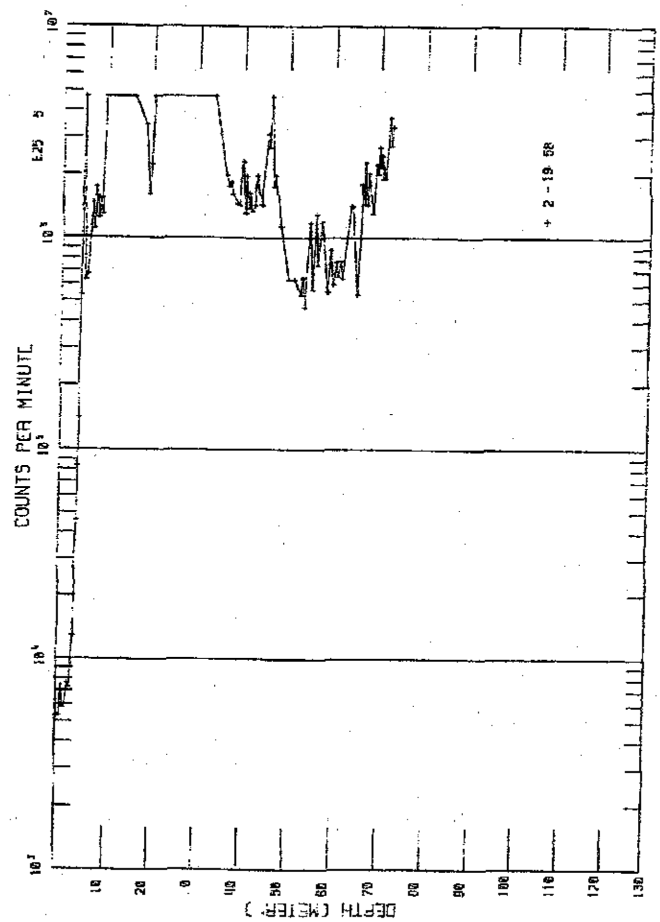
[1] GWL – groundwater level
[2] TOC – top of casing
[3] HWIS – Hanford Well Information System
[4] N/A – not applicable



from Additon et al. (1978)

Scintillation Probe Profiles for Borehole 299-E25-5, Logged on 2/19/58

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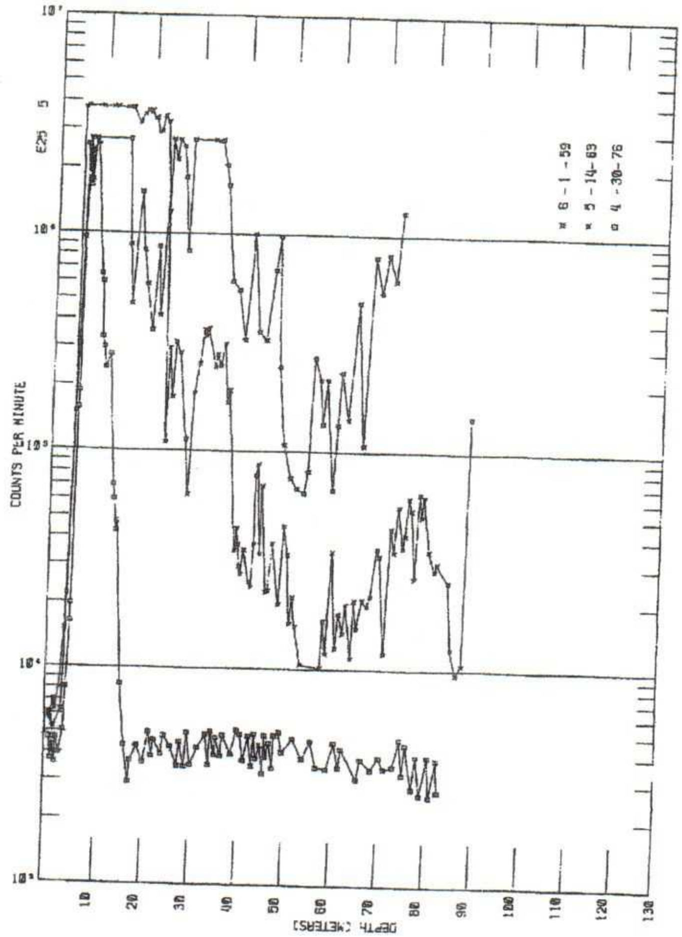
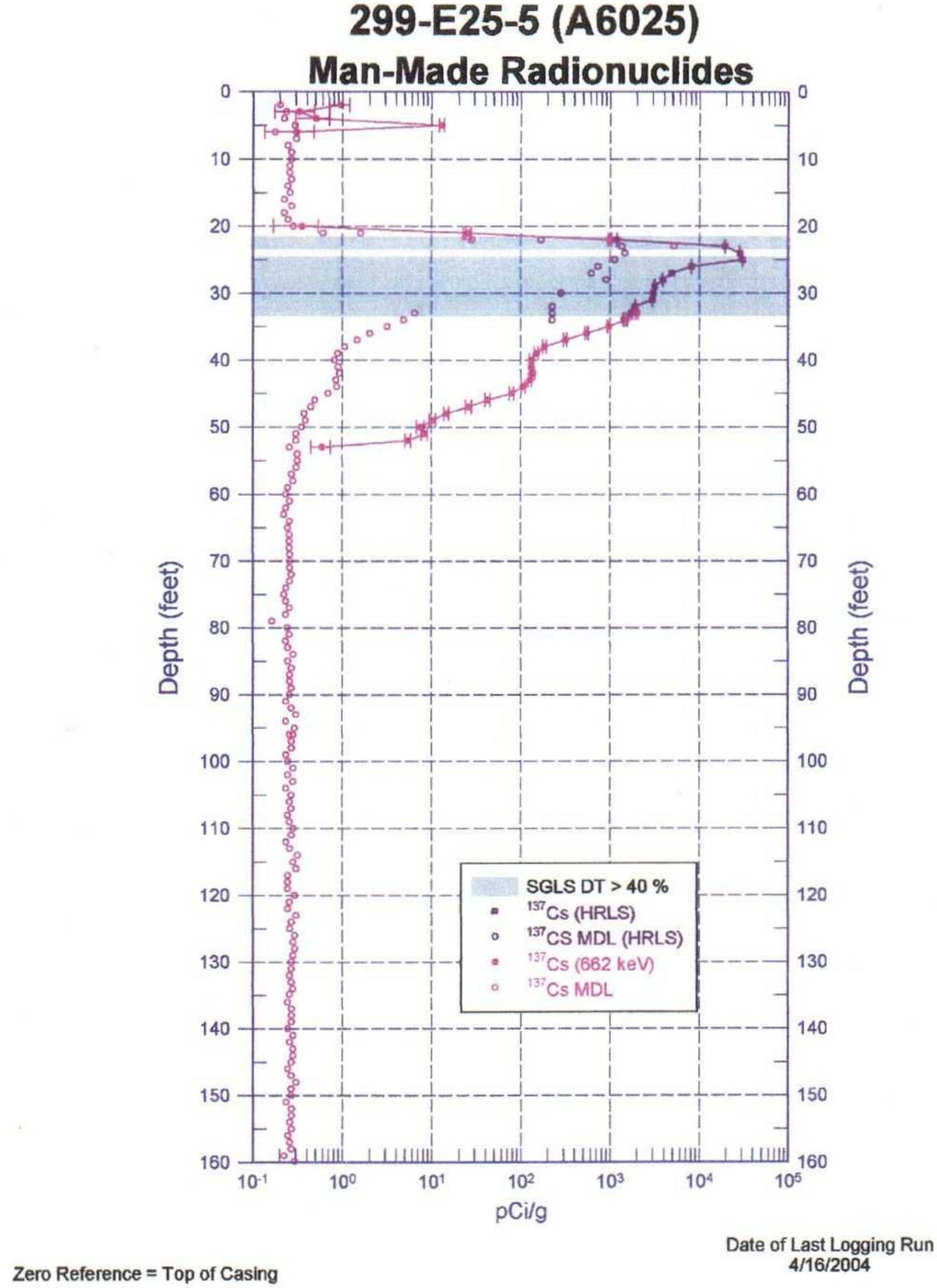


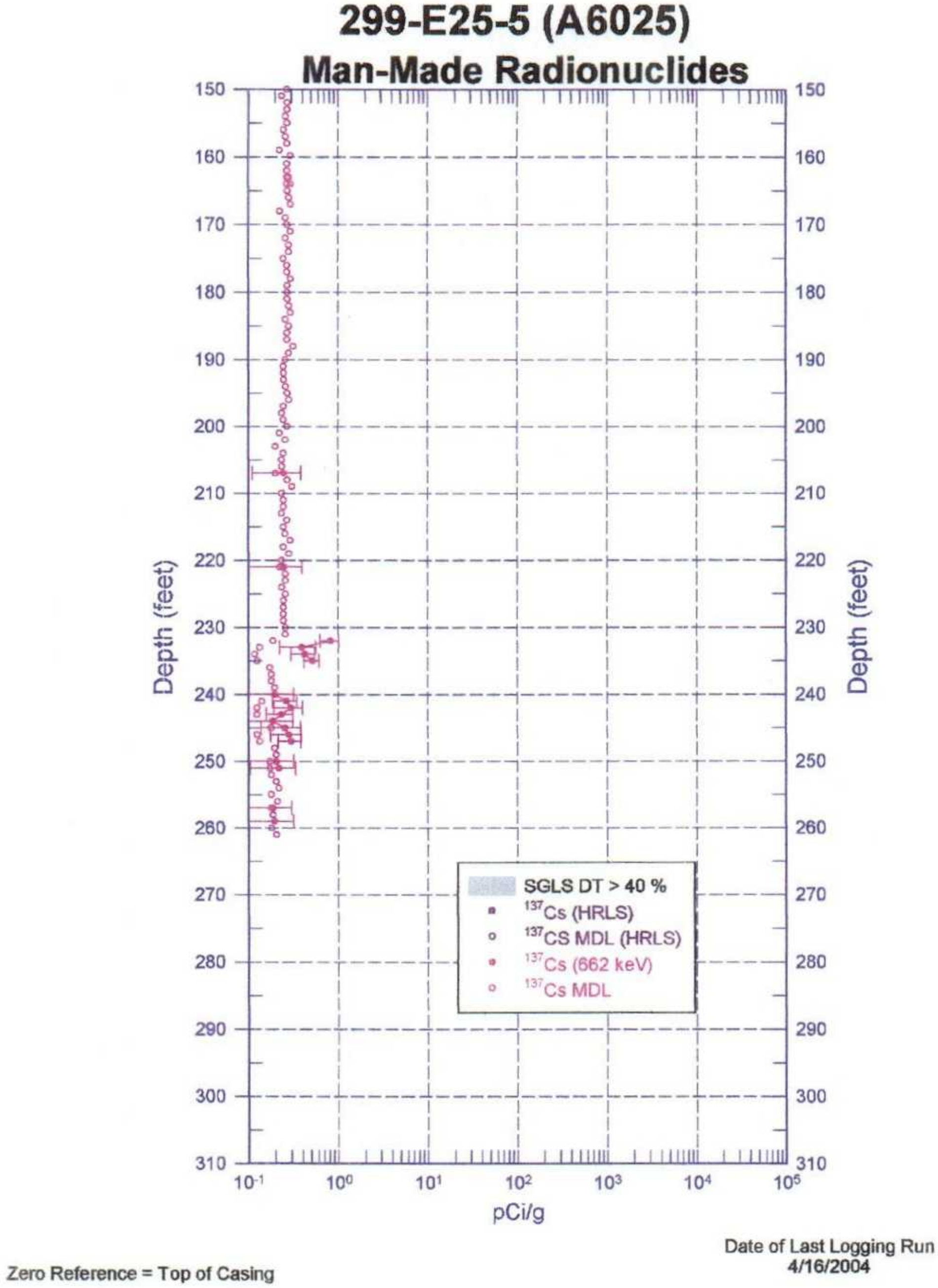
from Additon et al. (1978)

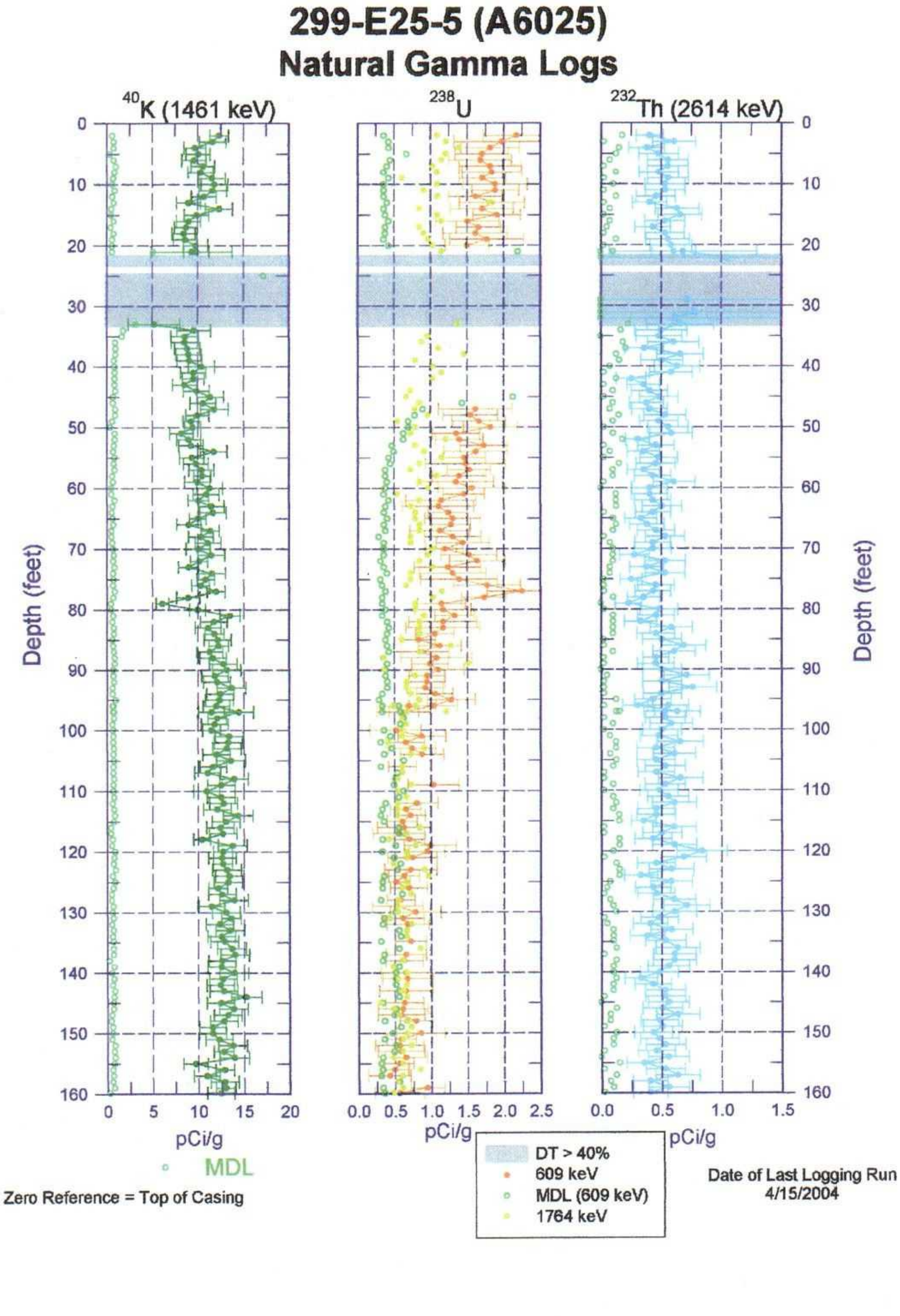
Scintillation Probe Profiles for Borehole 299-E25-5, Logged on 6/1/59, 5/14/63, and 4/30/76

Page 7



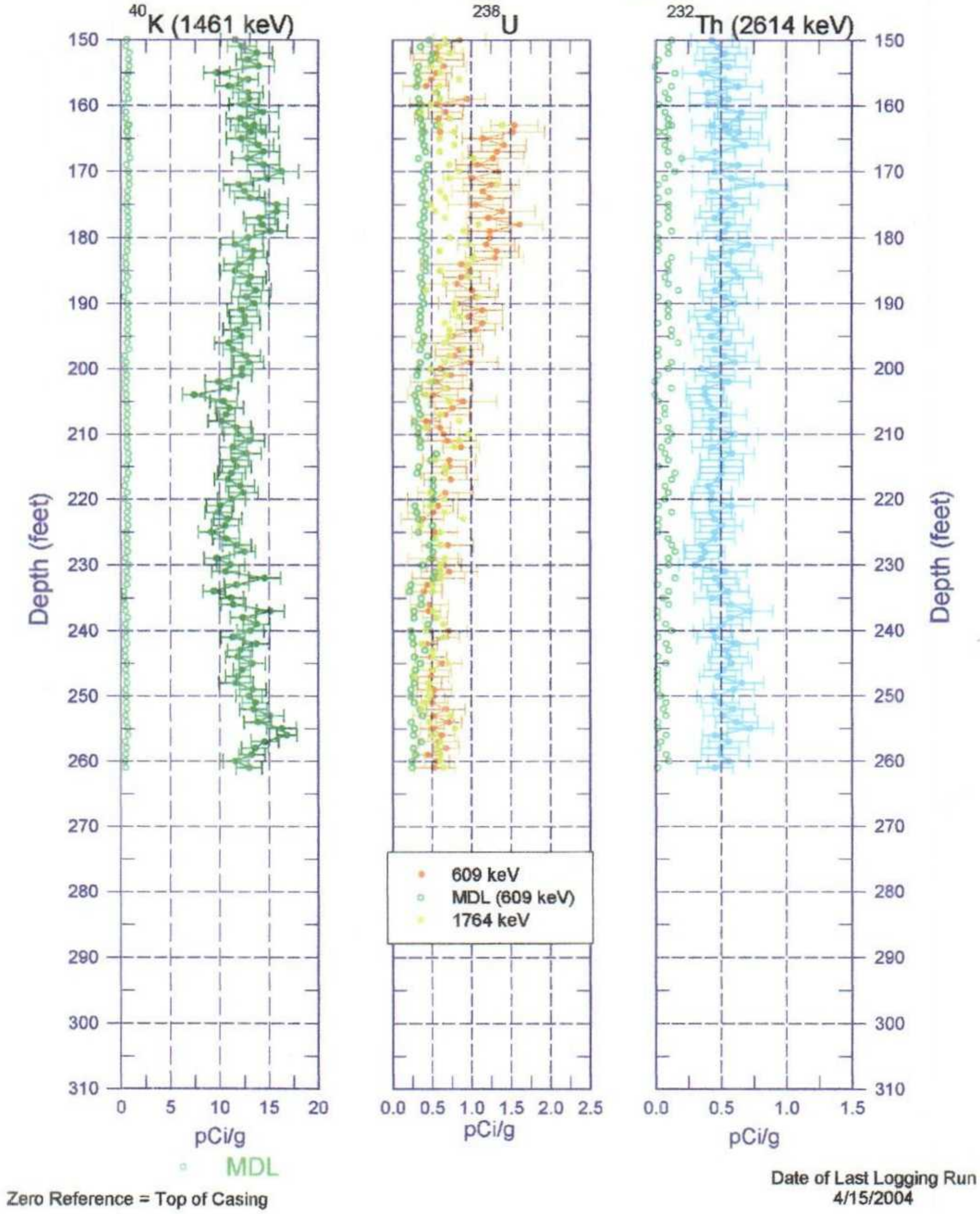
299-E25-5 (A6025)
Man-Made Radionuclides
Depth (feet)
pCi/g
SGLS DT > 40 %
137Cs (HRLS)
137CS MDL (HRLS)
137Cs (662 keV)
137Cs MDL
Zero Reference = Top of Casing
Date of Last Logging Run
4/16/2004

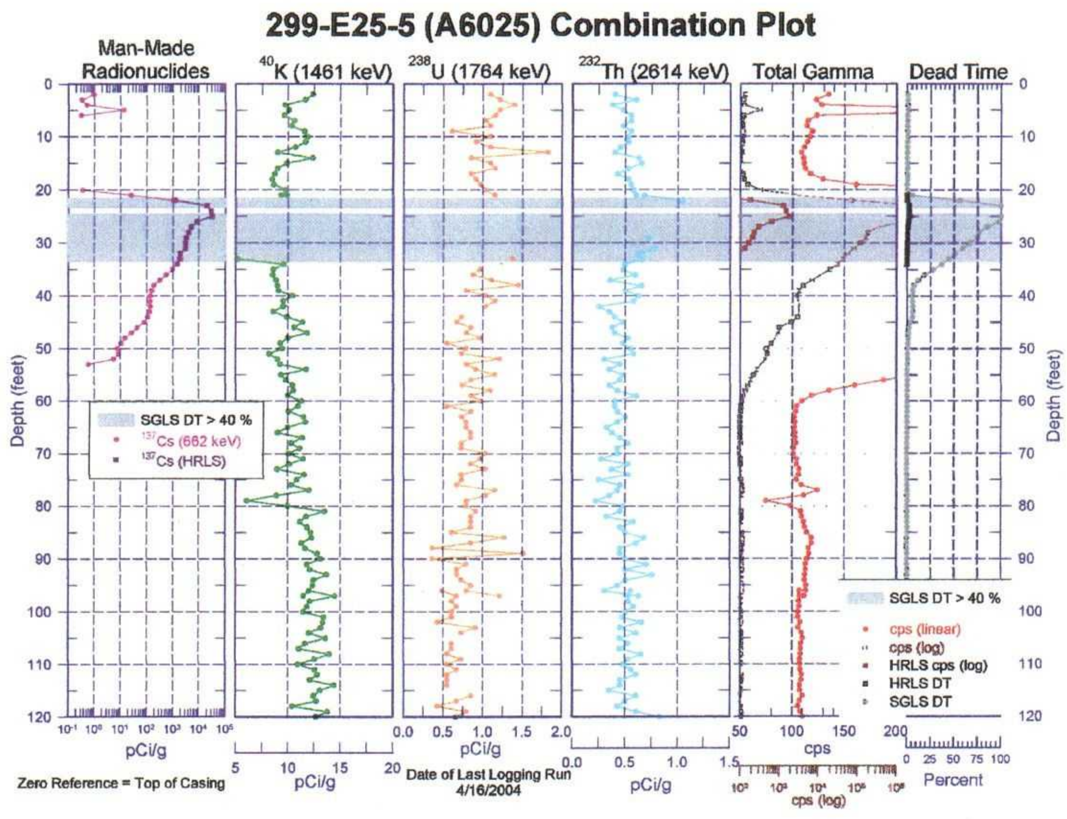

299-E25-5 (A6025)
Man-Made Radionuclides
Depth (feet)
pCi/g
SGLS DT > 40 %
137Cs (HRLS)
137CS MDL (HRLS)
137Cs (662 keV)
137Cs MDL
Zero Reference = Top of Casing
Date of Last Logging Run
4/16/2004

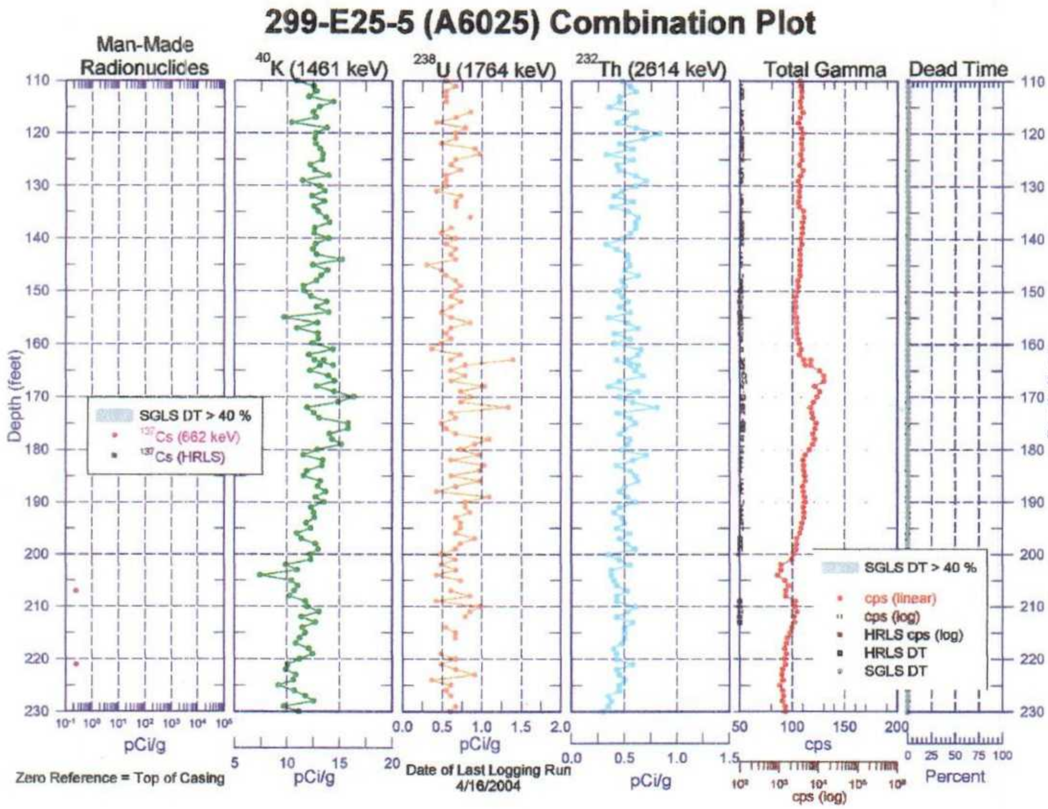


299-E25-5 (A6025)
Natural Gamma Logs
40K (1461 keV)
238U
232Th (2614 keV)
Depth (feet)
pCi/g
MDL
Zero Reference = Top of Casing
DT > 40%
609 keV
MDL (609 keV)
1764 keV
Date of Last Logging Run
4/15/2004

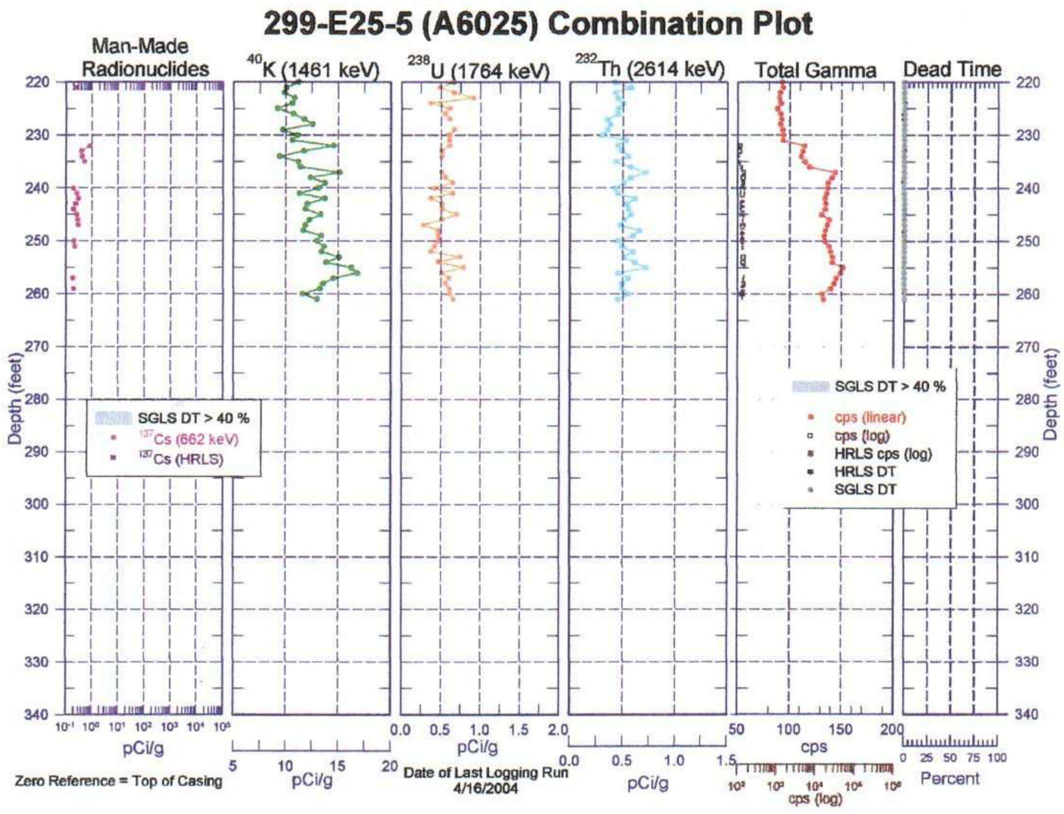
299-E25-5 (A6025)
Natural Gamma Logs



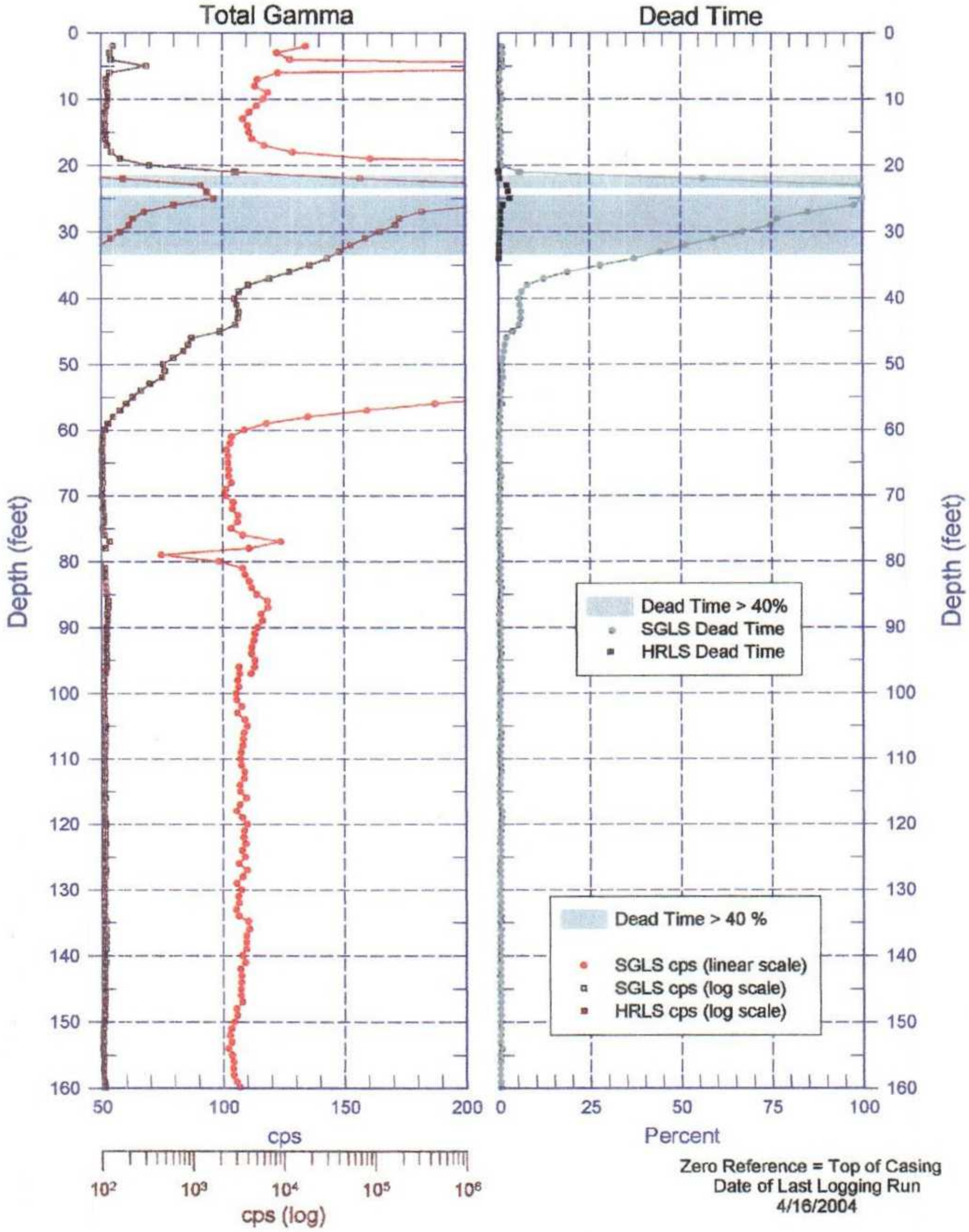

299-E25-5 (A6025) Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
SGLS DT > 40 %
137Cs (662 keV)
137Cs (HRLS)
pCi/g
Zero Reference = Top of Casing
Date of Last Logging Run 4/16/2004
cps
cps (log)
cps (linear)
HRLS cps (log)
HRLS DT
SGLS DT
Percent

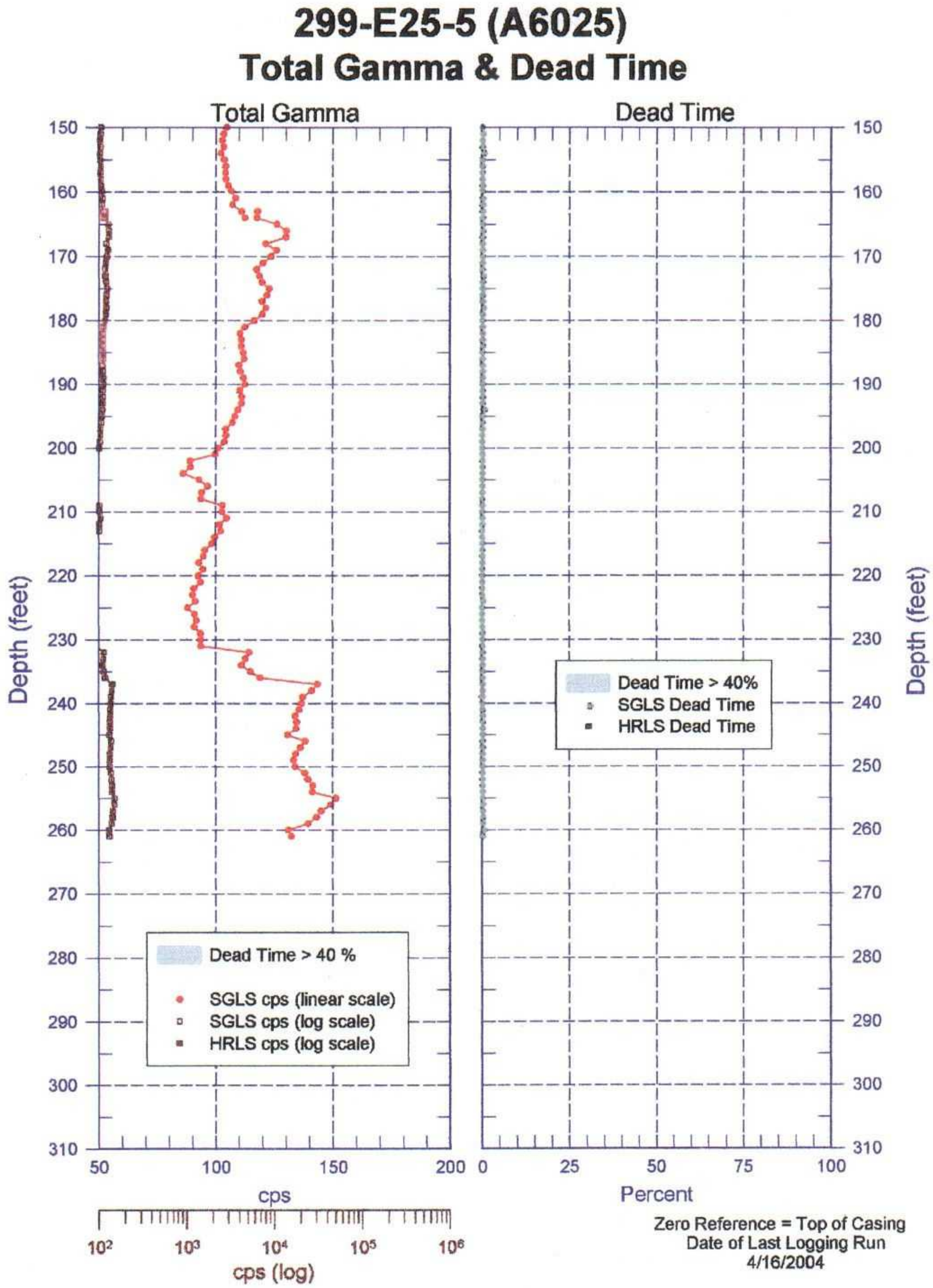


299-E25-5 (A6025) Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
SGLS DT > 40 %
137Cs (662 keV)
137Cs (HRLS)
cps (linear)
cps (log)
HRLS cps (log)
HRLS DT
SGLS DT
pCi/g
cps
cps (log)
Percent
Zero Reference = Top of Casing
Date of Last Logging Run
4/16/2004

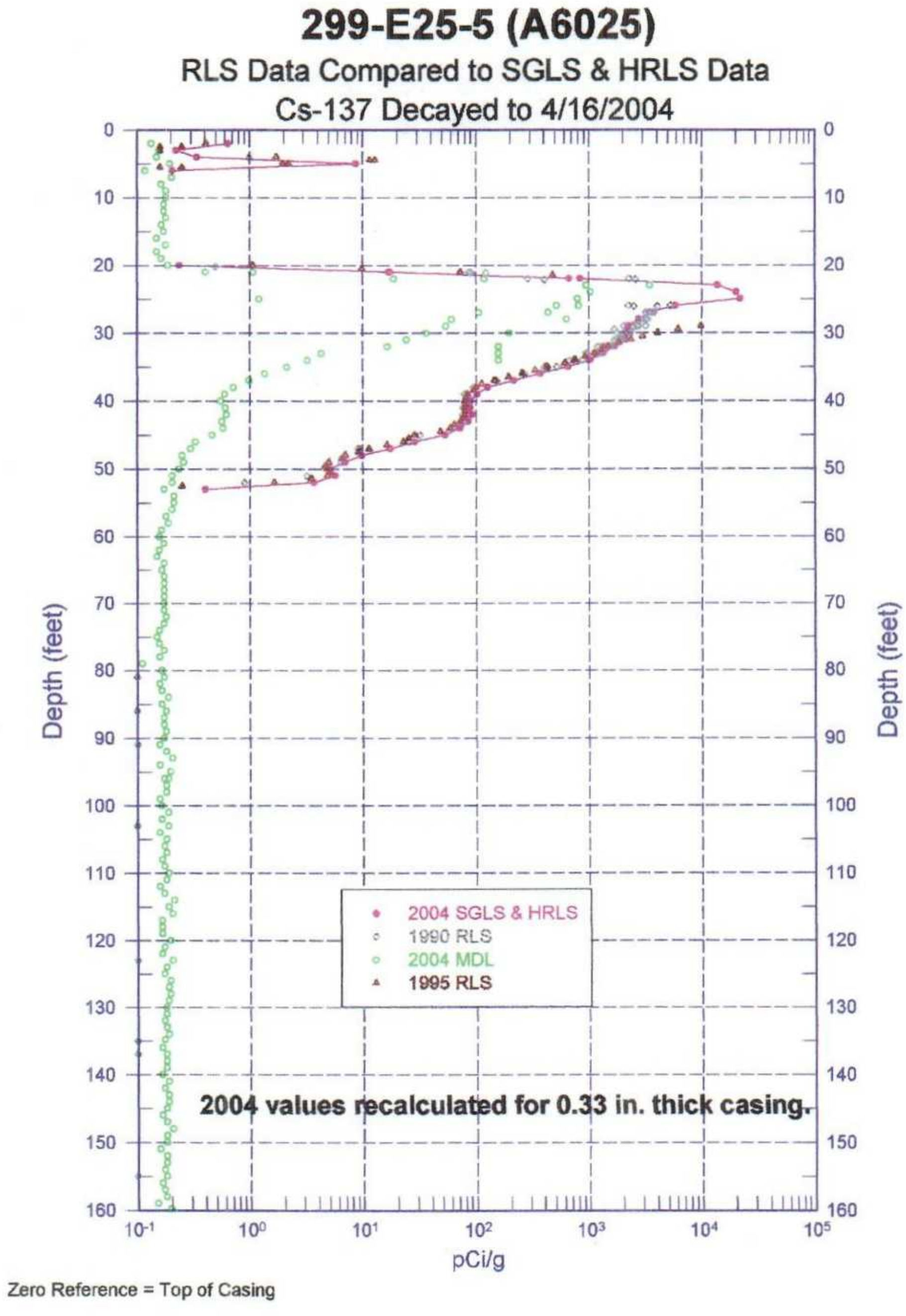

299-E25-5 (A6025) Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
SGLS DT > 40 %
137Cs (662 keV)
137Cs (HRLS)
cps (linear)
cps (log)
HRLS cps (log)
HRLS DT
SGLS DT
pCi/g
cps
cps (log)
Percent
Zero Reference = Top of Casing
Date of Last Logging Run
4/16/2004

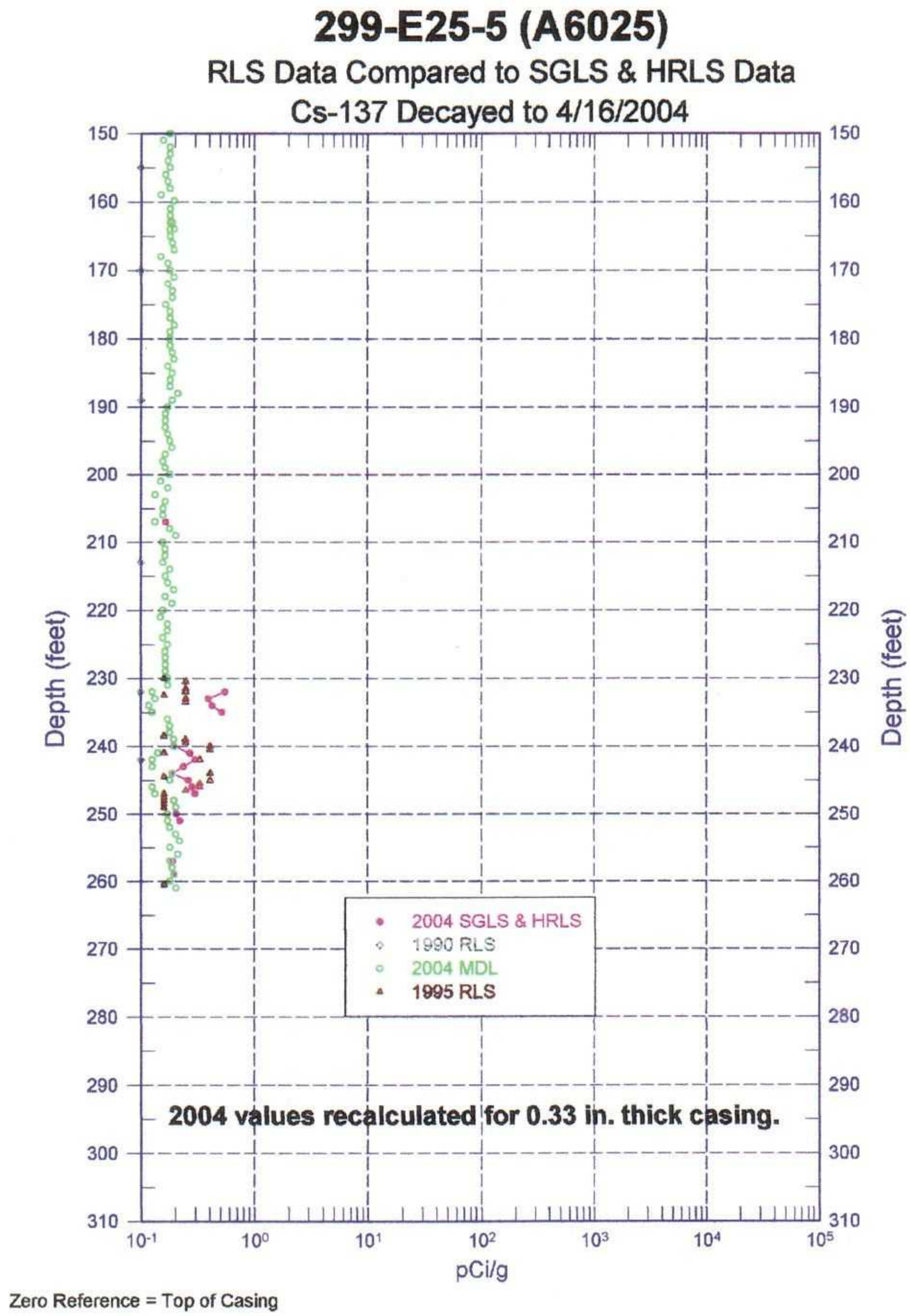
299-E25-5 (A6025)
Total Gamma & Dead Time

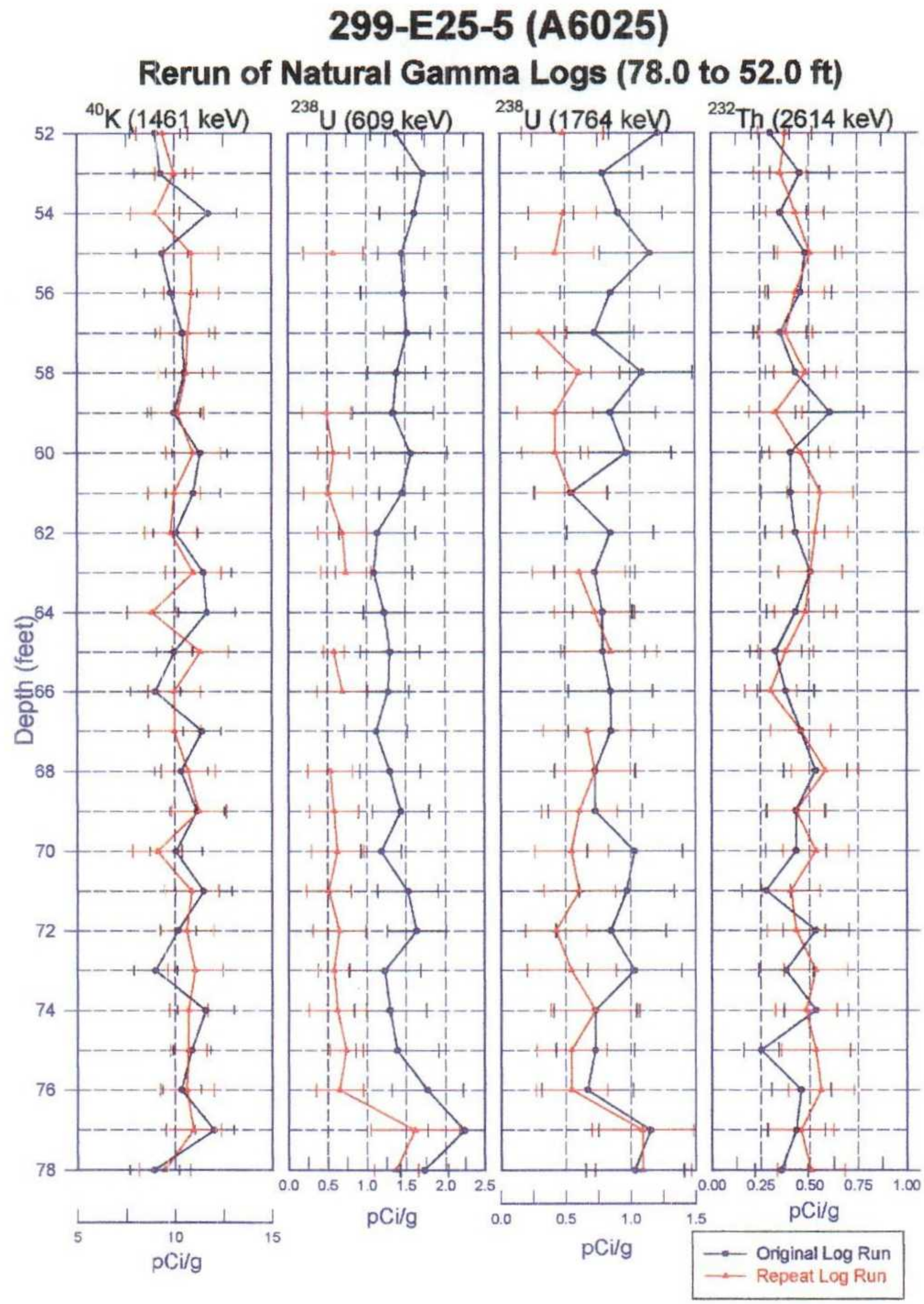


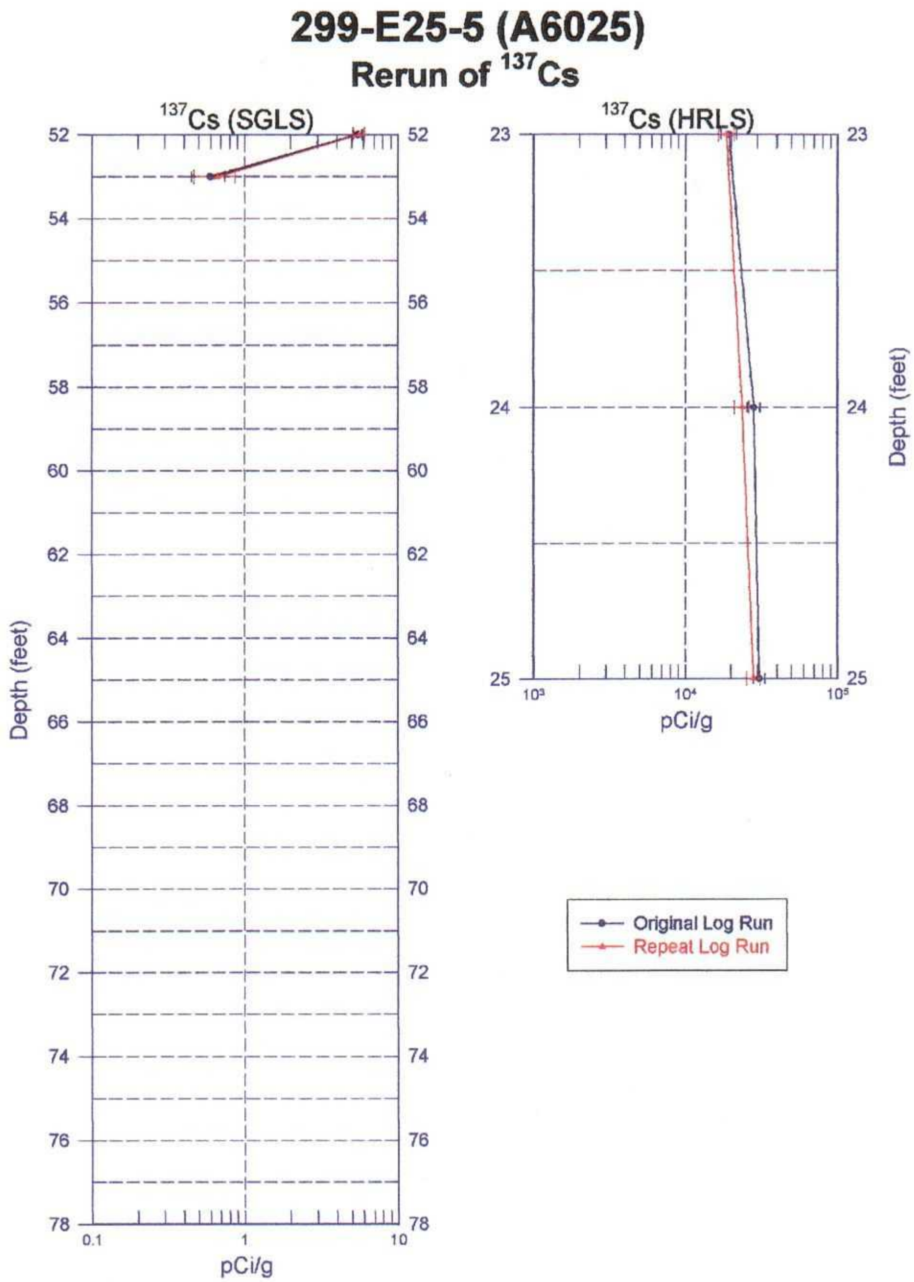


299-E25-5 (A6025)
Total Gamma & Dead Time
Total Gamma
Dead Time
Depth (feet)
Dead Time > 40 %
SGLS cps (linear scale)
SGLS cps (log scale)
HRLS cps (log scale)
Dead Time > 40%
SGLS Dead Time
HRLS Dead Time
cps
cps (log)
Percent
Zero Reference = Top of Casing
Date of Last Logging Run
4/16/2004


299-E25-5 (A6025)
RLS Data Compared to SGLS & HRLS Data
Cs-137 Decayed to 4/16/2004
Depth (feet)
pCi/g
2004 SGLS & HRLS
1990 RLS
2004 MDL
1995 RLS
2004 values recalculated for 0.33 in. thick casing.
Zero Reference = Top of Casing


299-E25-5 (A6025)
RLS Data Compared to SGLS & HRLS Data
Cs-137 Decayed to 4/16/2004
Depth (feet)
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
2004 SGLS & HRLS
1990 RLS
2004 MDL
1995 RLS
2004 values recalculated for 0.33 in. thick casing.
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}
pCi/g
Zero Reference = Top of Casing


299-E25-5 (A6025)
Rerun of Natural Gamma Logs (78.0 to 52.0 ft)
40K (1461 keV)
238U (609 keV)
238U (1764 keV)
232Th (2614 keV)
Depth (feet)
pCi/g
Original Log Run
Repeat Log Run


299-E25-5 (A6025)
Rerun of 137Cs
137Cs (SGLS)
137Cs (HRLS)
Depth (feet)
pCi/g
0.1
1
10
52
54
56
58
60
62
64
66
68
70
72
74
76
78
23
24
25
10³
10⁴
10⁵
Original Log Run
Repeat Log Run

Hanford Office DOE-EM/GJ707-2004

299-E25-6 (A4796)
Log Data Report

Borehole Information:

Borehole:	299-E25-6 (A4796)		Site:	216-A-8 Crib	
Coordinates (WA State Plane)		GWL (ft)[1]:	263.7	GWL Date:	07/07/2004
North	East	Drill Date	TOC[2] Elevation	Total Depth (ft)	Type
136,163.971 m	575,683.761 m	April 1956	202.603 m	290	Cable Tool

Casing Information:

Casing Type	Stickup (ft)	Outer Diameter (in.)	Inside Diameter (in.)	Thickness (in.)	Top (ft)	Bottom (ft)
Welded steel	+2.4	6 5/8	6 1/8	1/4	+2.40	229
Welded steel	0	8	unknown	unknown		290

The logging engineer used a caliper to determine the outside casing diameter. The caliper and casing stickup were both measured using a steel tape. Inside casing diameter was measured with a steel tape. All measurements were rounded to the nearest 1/16 in. Bottom is reported from *Hanford Wells* (Chamness and Merz 1993). The 8-in. casing was not observed at the ground surface.

Borehole Notes:

Borehole coordinates, elevation, and well construction information are from measurements by Stoller field personnel, HWIS[3], and Ledgerwood (1993). Zero reference is the top of the 6-in. casing. Before logging began, Duratek well services removed a pump and rods from the borehole.

Logging Equipment Information:

Logging System:	Gamma 2A		Type: 35% HPGe (34TP20893A)
Calibration Date:	03/2004	Calibration Reference:	DOE-EM/GJ642-2004
		Logging Procedure:	MAC-HGLP 1.6.5, Rev. 0

Spectral Gamma Logging System (SGLS) Log Run Information:

Log Run	1	2	3	4	5 / Repeat
Date	07/01/04	07/06/04	07/07/04	07/08/04	07/08/04
Logging Engineer	Spatz	Spatz	Spatz	Spatz	Spatz
Start Depth (ft)	26.0	80.0	263.0	156.0	78.0
Finish Depth (ft)	3.0	25.0	155.0	79.0	52.0
Count Time (sec)	200	200	200	200	200
Live/Real	R	R	R	R	R
Shield (Y/N)	N/A[4]	N/A	N/A	N/A	N/A
MSA Interval (ft)	1.0	1.0	1.0	1.0	1.0
ft/min	N/A	N/A	N/A	N/A	N/A
Pre-Verification	BA358CAB	BA360CAB	BA361CAB	BA362CAB	BA362CAB

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Log Run	1	2	3	4	5 / Repeat
Start File	BA359000	BA360000	BA361000	BA362000	BA362078
Finish File	BA359023	BA360055	BA361108	BA362077	BA362104
Post-Verification	BA359CAA	BA360CAA	BA361CAA	BA362CAA	BA362CAA
Depth Return Error (in.)	0	0	+ 1/2	N/A	0
Comments	Before logging began a fine gain adjustment was made.	No fine gain adjustment made.	Fine gain adjustment made after files -013, -053, and -098.	Fine gain adjustment made after files -012, -042, -057, and -069.	Fine gain adjustment made after file -091.

Logging Operation Notes:

Zero reference was top of the 6-in. casing. Logging was performed without the centralizer on the sonde for spectral data collected between 263 and 155 ft. Pre- and post-survey verification measurements for the SGLS employed the Amersham KUT (^{40}K, ^{238}U, and ^{232}Th) verifier with serial number 082.

Analysis Notes:

Analyst:	McCain	Date:	08/11/04	Reference:	GJO-HGLP 1.6.3, Rev. 0

SGLS pre-run and post-run verification spectra were collected at the beginning and end of each day. Net count rates for the 609-keV and 1461-keV gamma lines were within verification criteria, but net count rates for the 2614-keV gamma line were below the acceptance criteria in 4 of 8 verification spectra. All results were within the HASQARD 20% limits. Peak width (fwhm) values tended to be above the verification criteria, particularly for the 2614-keV gamma line. Examination of the individual spectra indicated the system appears to be functioning normally, and the spectra are provisionally accepted.

Log spectra for the SGLS were processed in batch mode using APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Pre-run verification spectra were used to determine the energy and resolution calibration for processing the data using APTEC SUPERVISOR. Concentrations were calculated in EXCEL (source file: G2AMar04.xls), using parameters determined from analysis of recent calibration data. Zero reference was the top of the 6-in. casing. The casing configuration was assumed to consist of an 8-inch casing from the ground surface to 290 ft, with a 6-inch casing inside the 8-inch casing to a depth of 229 ft. Casing thickness values are published values for ASTM schedule-40 steel pipe. A total casing thickness of 0.602 in. (0.280 + 0.322) was used from the ground surface to 229 ft, and 0.322 was used from 229 ft to 290 ft. The maximum log depth was 263 ft. The well construction and completion summary indicates the 8-inch casing was perforated from 0 to 5 ft and 20 to 224 ft and that the annular space between the 6-inch casing and 8-inch casing was filled with cement grout. No correction was applied for the grout, and it is likely that concentration values are slightly underestimated above 224 ft.

Log Plot Notes:

Separate log plots are provided for gross gamma and dead time, naturally occurring radionuclides (^{40}K, ^{238}U, and ^{232}Th), and man-made radionuclides. Plots of the repeat logs versus the original logs are included. For each radionuclide, the energy value of the spectral peak used for quantification is indicated. Unless otherwise noted, all radionuclides are plotted in picocuries per gram (pCi/g). The open circles indicate the minimum detectable level (MDL) for each radionuclide. Error bars on each plot represent error associated with counting statistics only and do not include errors associated with the inverse efficiency function, dead time correction, or casing correction. These errors are discussed in the calibration report. A combination plot is also included to facilitate correlation. The ^{214}Bi peak at 1764 keV was used to determine the naturally occurring ^{238}U concentrations on the combination plot rather than the ^{214}Bi peak at 609 keV because it exhibited slightly higher net counts per second.

Results and Interpretations:

^{137}Cs was the only man-made radionuclide detected in this borehole. ^{137}Cs was detected in three intervals: (1) between 9- and 11-ft depth, with a maximum concentration of 9.8 pCi/g; (2) between 22 and 73 ft, with a maximum concentration of 50 pCi/g at 25 to 30 ft, gradually decreasing to the MDL of about 0.25 to 0.30 pCi/g at 73 ft; and (3) between 227 and 234 ft, with a maximum concentration of 3.2 pCi/g. ^{137}Cs was also detected sporadically at or near the MDL (0.3 pCi/g) at 138 ft, 212 ft, and 243 to 250 ft.

The plots of the repeat logs demonstrate reasonable repeatability of the SGLS data for the natural radionuclides (609, 1461, 1764, and 2614 keV) and ^{137}Cs.

Plots comparing RLS data from August 1990 to SGLS data are also provided. The RLS ^{137}Cs values have been corrected to account for differences in casing thickness assumptions and decayed to July 2004. The corrected 1990 values are significantly lower than the 2004 values. However, both log curves reflect a similar contaminant profile. The apparent discrepancy in ^{137}Cs values is most likely due to differences in system calibration assumptions.

Gross gamma logs digitized from Additon et al. (1977) are also shown. These logs were converted to counts per second versus depth in feet for better comparison with RLS and SGLS data. As early as 1958, a zone of high gamma activity is observed from approximately 15- to 60-ft depth. Within this interval, the detector appears to be saturated. The 1958 and 1959 logs show abrupt increases in gamma activity at the bottom of the logged interval at 230 to 240 ft. This may indicate contamination at or near groundwater level. By 1963, the interval of detector saturation extends to about 105 ft. Gamma activity levels have increased significantly between 105 and 135 ft, and there appears to be an abrupt decrease at 135 ft, suggesting additional contamination events and/or downward contaminant migration between 1959 and 1963. The 1968 and 1976 logs show significantly lower gamma activity levels and generally reflect the profile of the 1990 RAS and 2004 SGLS logs. Below 40- to 60-ft depth, the dominant contaminant may have been a radionuclide with a relatively short half life, such as ^{106}Ru.

The 1976 log shows significantly greater gamma activity between approximately 20 to 75 ft. This may indicate an additional contamination event between 1968 and 1976.

The SGLS ^{137}Cs log indicates contaminant migration to a depth of 74 ft. The historical data suggest contaminants from the 216-A-8 Crib reached at least 135-ft depth.

The SGLS log also detected ^{137}Cs between 227 and 234 ft, with a maximum concentration of about 3.2 pCi/g at 229 ft. Traces of ^{137}Cs were also detected intermittently between 243 and 251 ft. The source of this contamination is not known. Other boreholes in the vicinity also exhibit similar contamination profiles at approximately the same elevation. This contamination may have been deposited on the casing from groundwater contaminant plumes in the past when groundwater levels were higher.

References:

Additon, M.K., K.R. Fecht, T.L. Jones, and G.V. Last, 1978. *Scintillation Probe Profiles From 200 East Area Crib Monitoring Wells*, RHO-LD-28, Rockwell Hanford Operations, Richland, Washington.

Chamness, M.A., and J.K. Merz, 1993. *Hanford Wells*, PNL-8800, Pacific Northwest Laboratory, Richland, Washington.

Ledgerwood, R.K., 1993. *Summaries of Well Construction Data and Field Observations for Existing 200-East Resource Protection Wells*, WHC-SD-ER-TI-007, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

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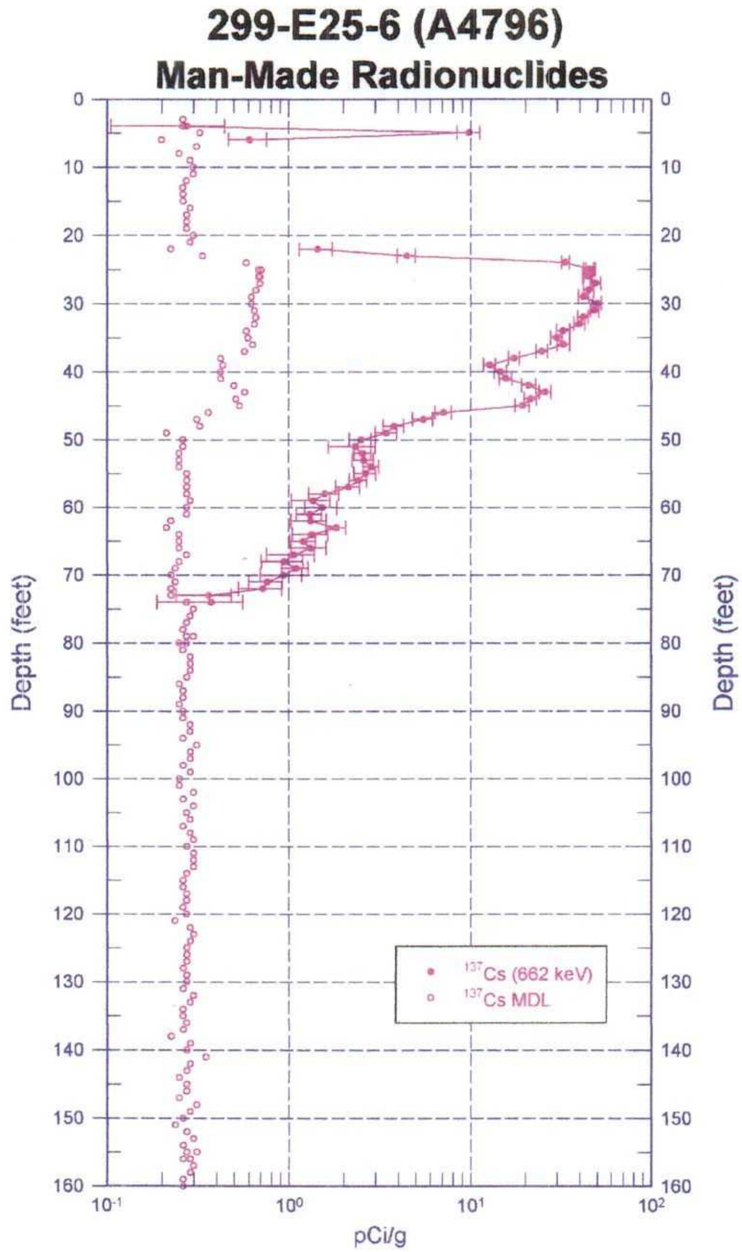
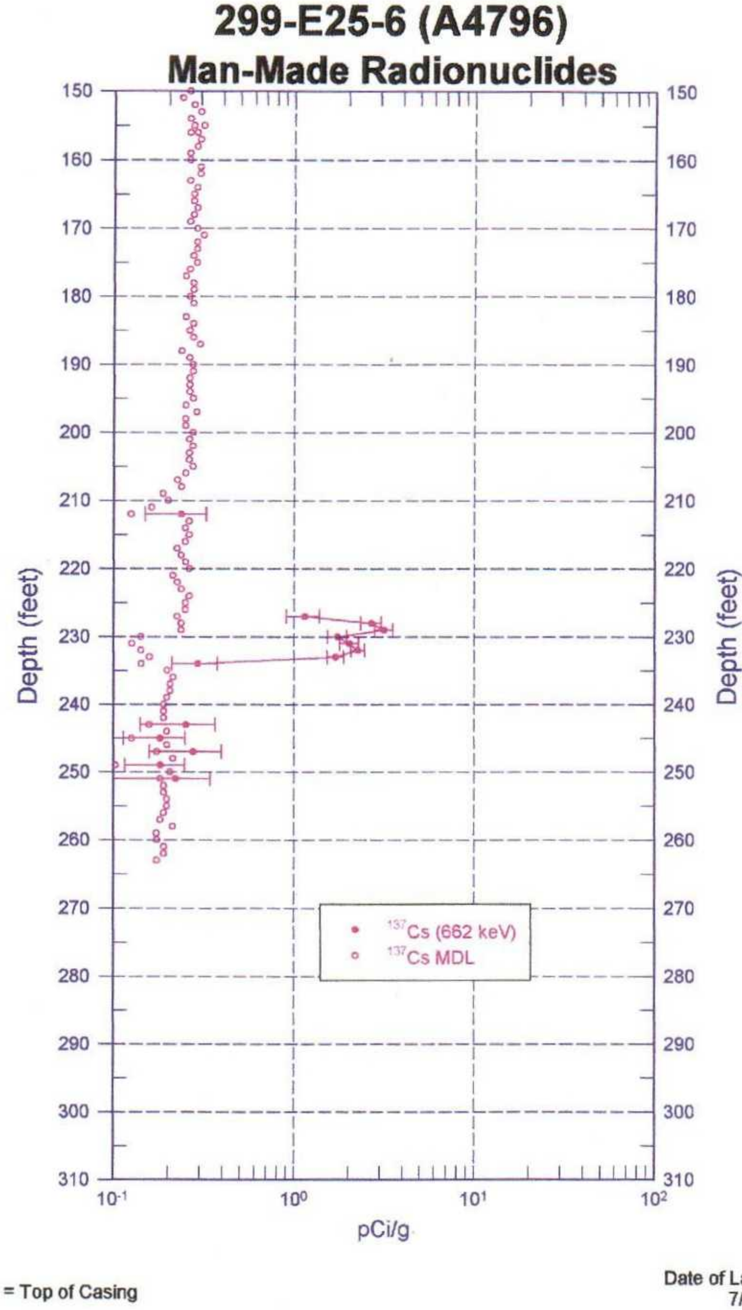
[1] GWL – groundwater level
[2] TOC – top of casing
[3] HWIS – Hanford Well Information System
[4] N/A – not applicable



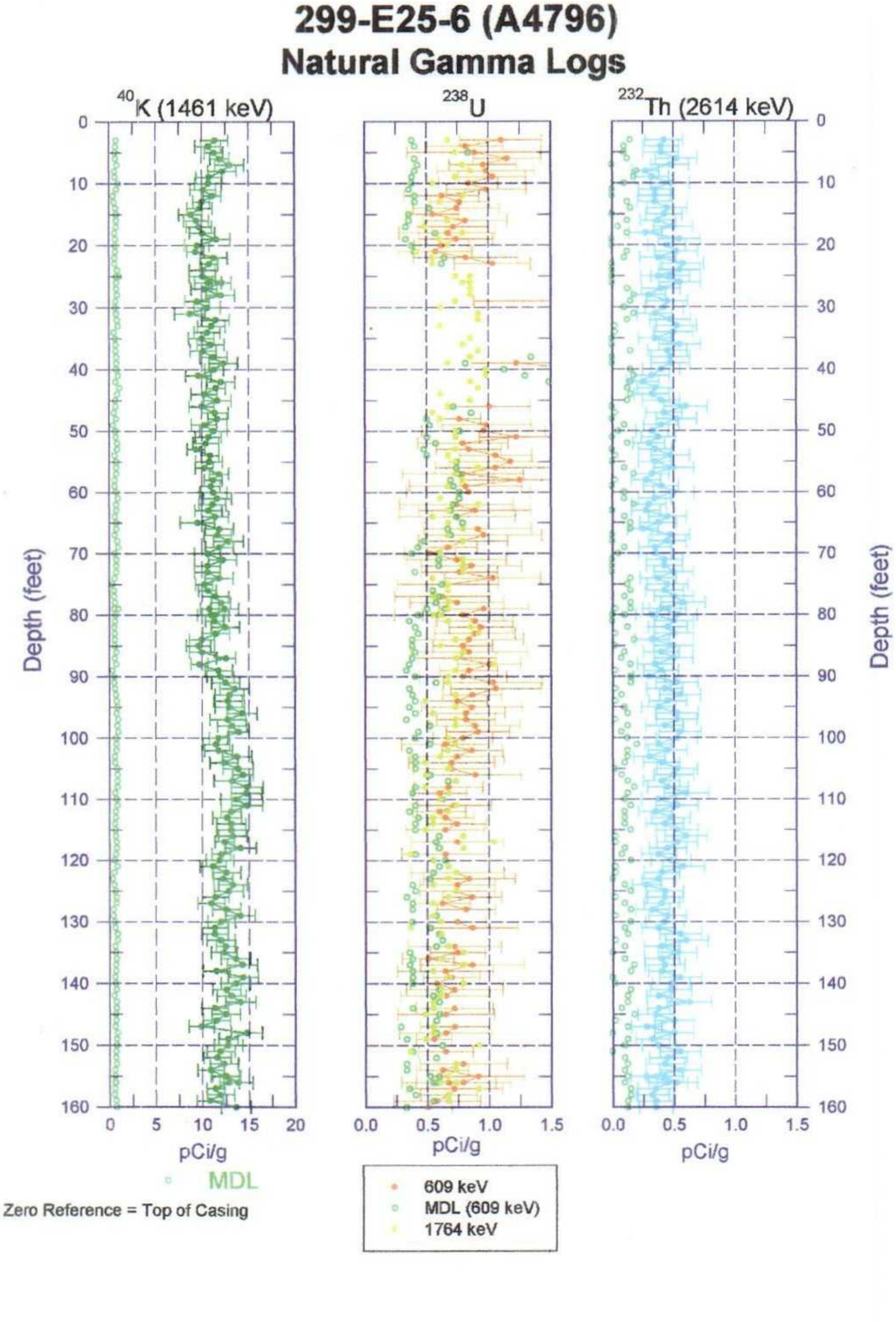
Zero Reference = Top of Casing

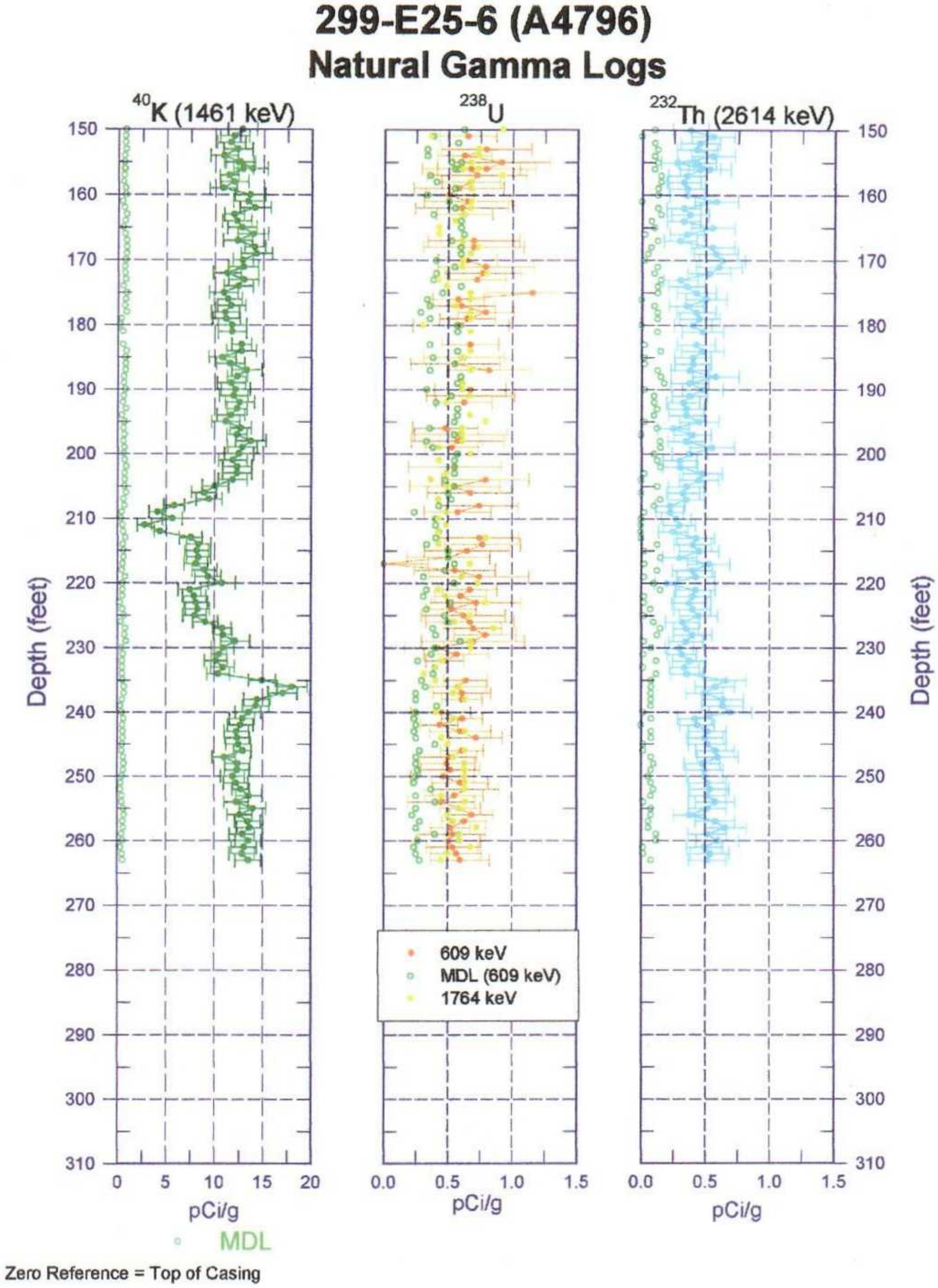
Date of Last Logging Run
7/08/2004



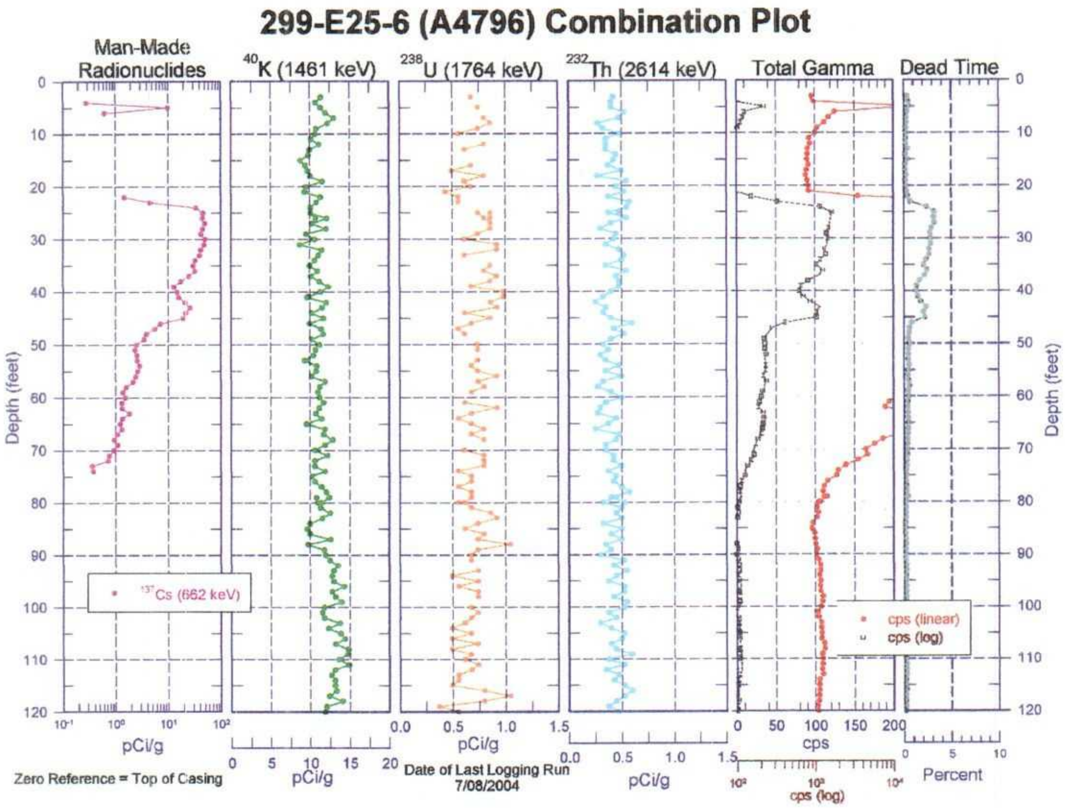
Zero Reference = Top of Casing

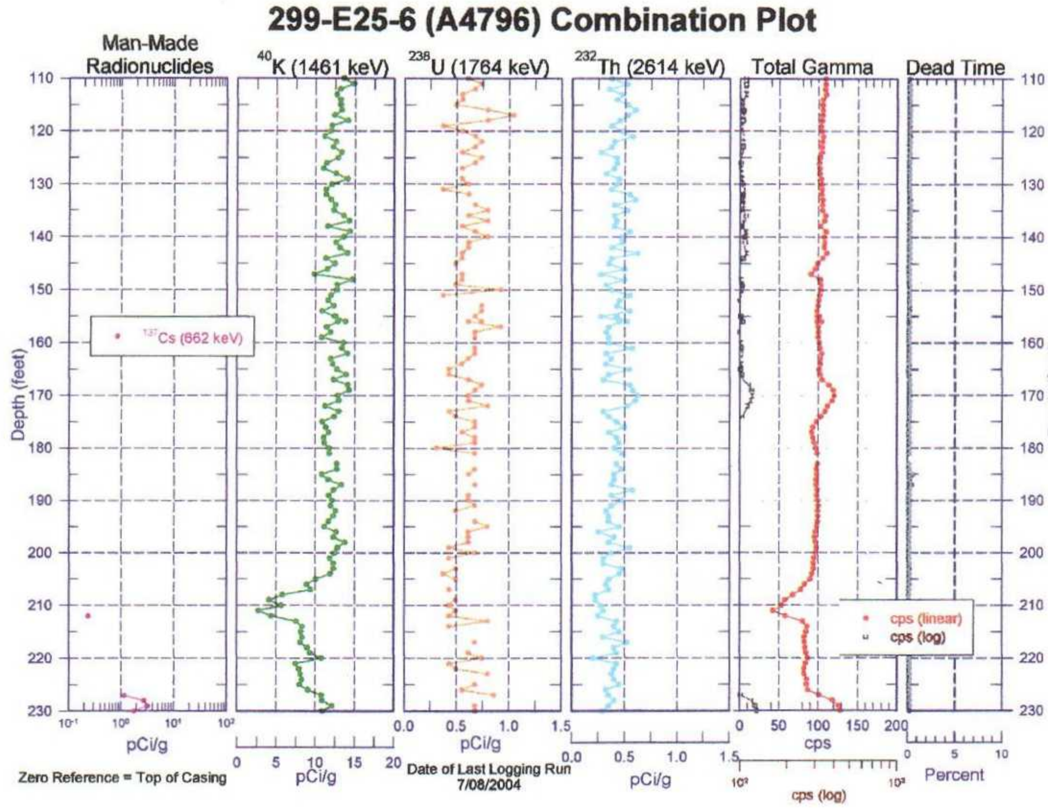
Date of Last Logging Run
7/08/2004

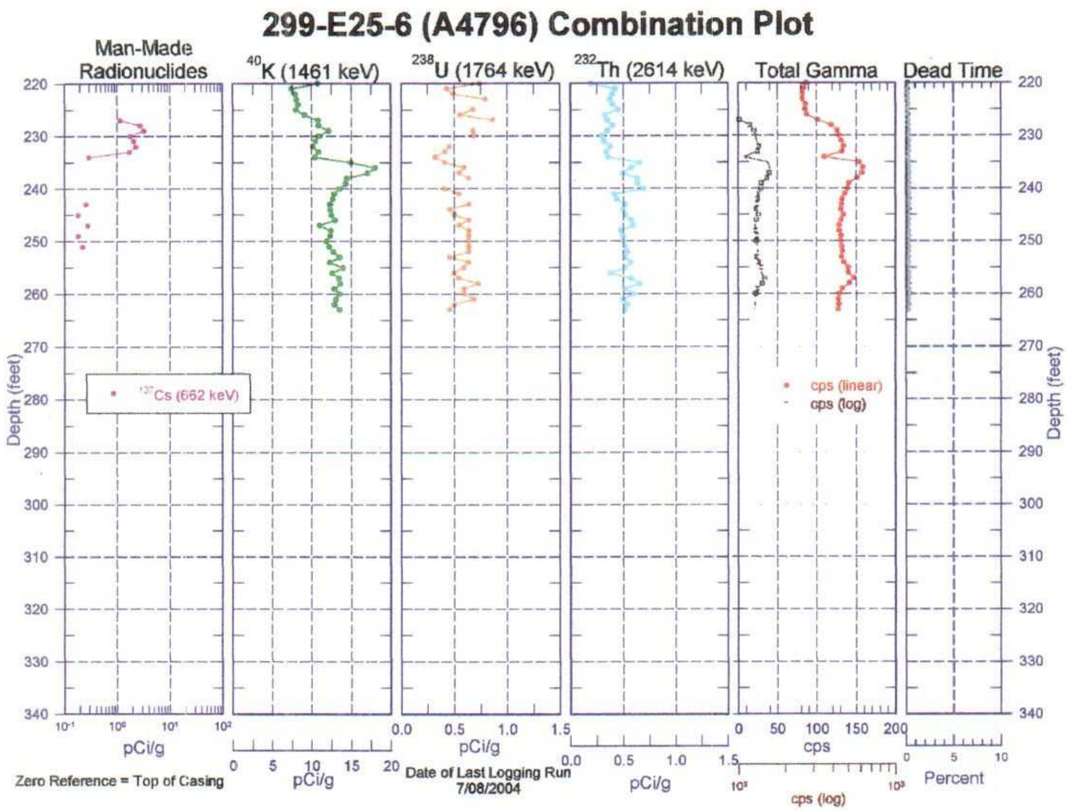

299-E25-6 (A4796)
Natural Gamma Logs
40K (1461 keV)
238U
232Th (2614 keV)
Depth (feet)
pCi/g
MDL
Zero Reference = Top of Casing
609 keV
MDL (609 keV)
1764 keV



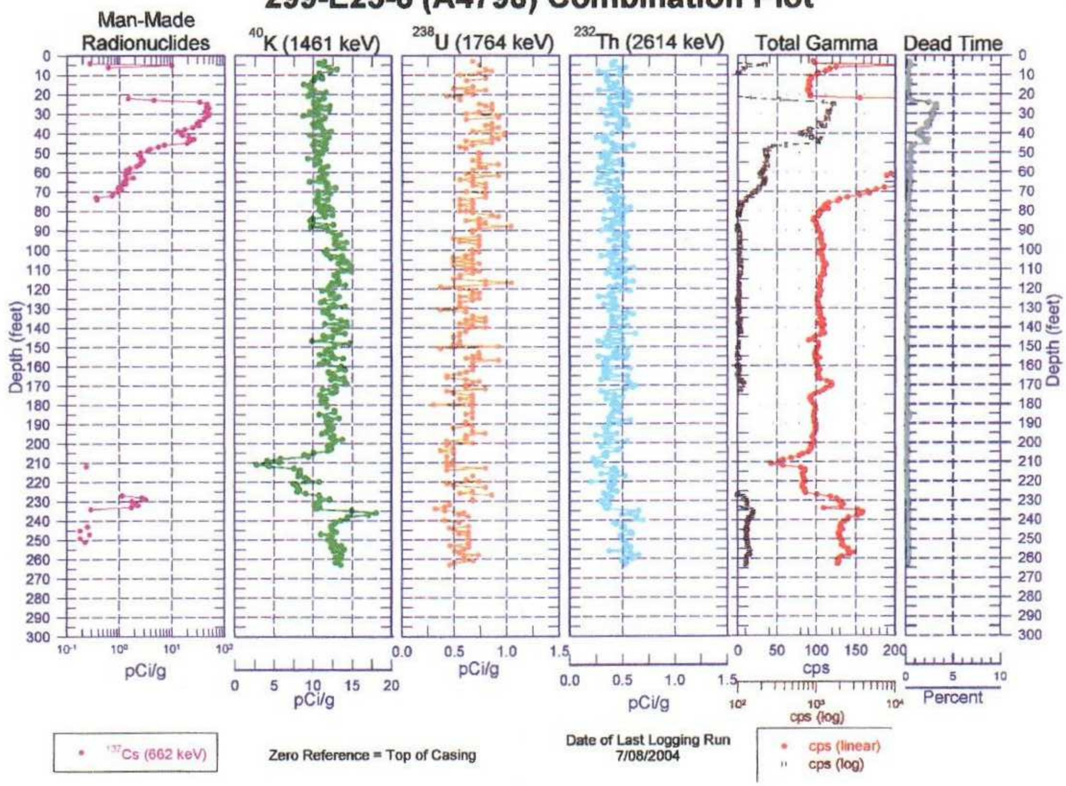
299-E25-6 (A4796)
Natural Gamma Logs
40K (1461 keV)
238U
232Th (2614 keV)
Depth (feet)
pCi/g
MDL
609 keV
MDL (609 keV)
1764 keV
Zero Reference = Top of Casing

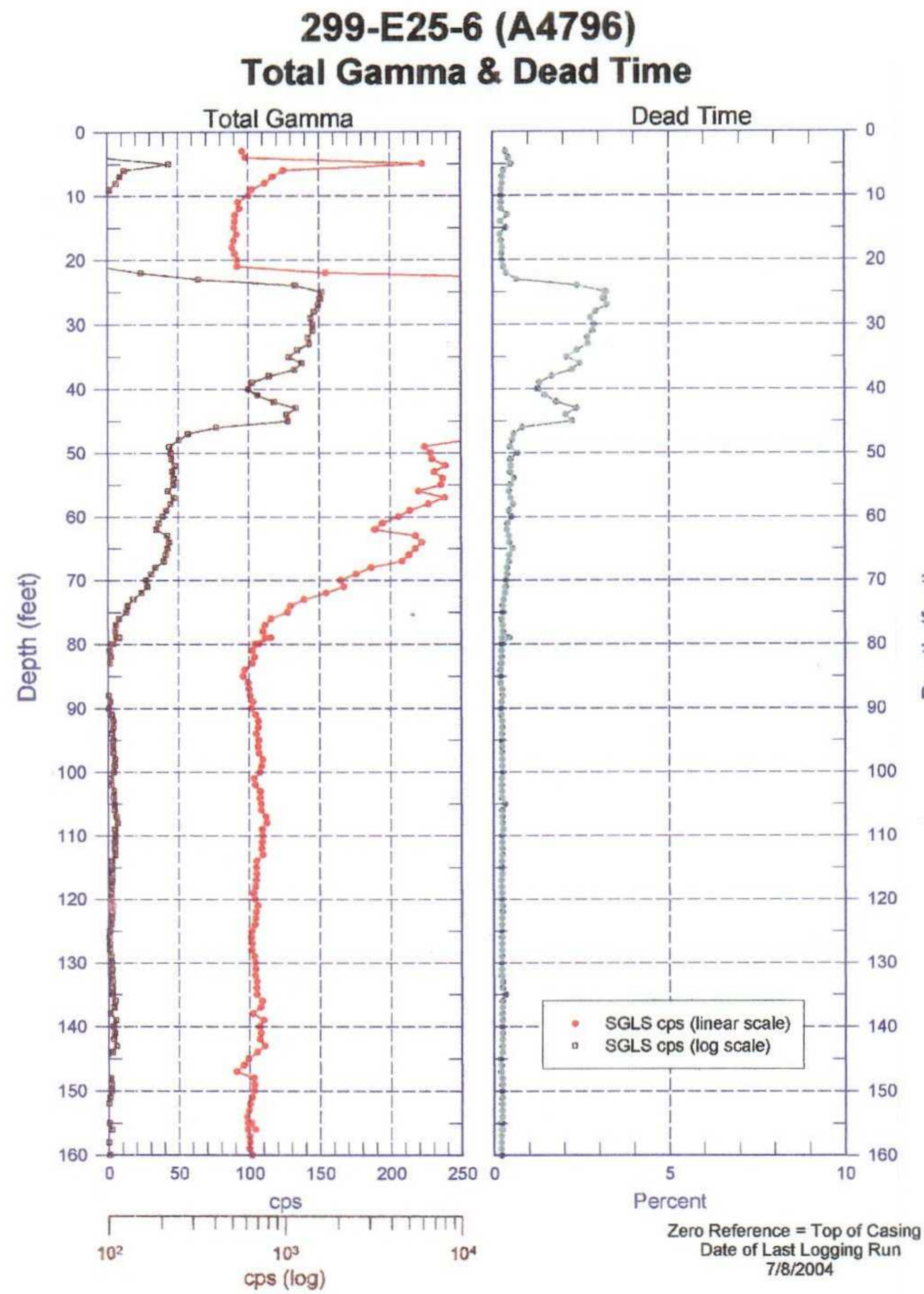

299-E25-6 (A4796) Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
137Cs (662 keV)
cps (linear)
cps (log)
pCi/g
cps
cps (log)
Percent
Zero Reference = Top of Casing
Date of Last Logging Run
7/08/2004

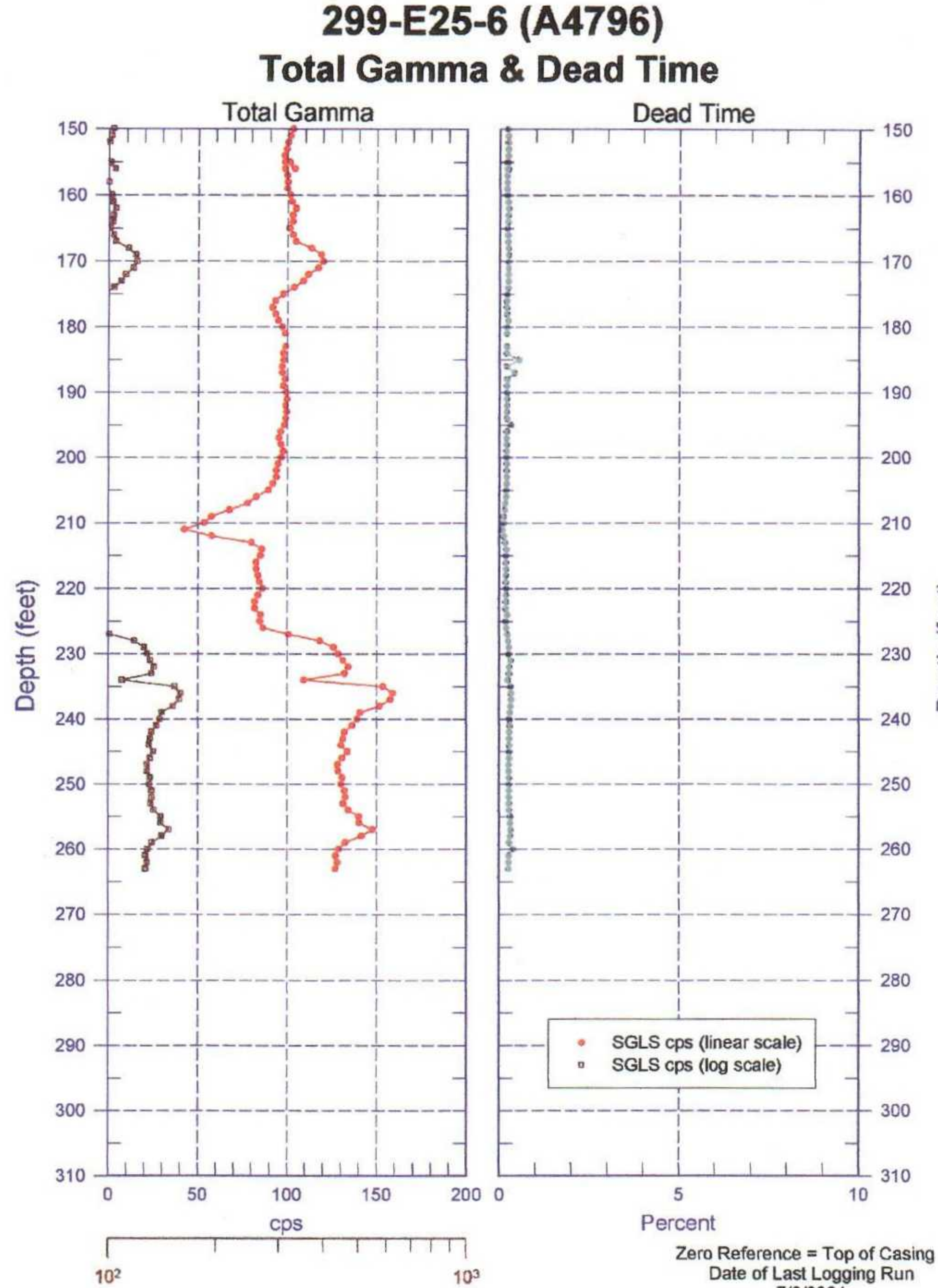

299-E25-6 (A4796) Combination Plot
Man-Made Radionuclides
^{40}K (1461 keV)
^{238}U (1764 keV)
^{232}Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
^{137}Cs (662 keV)
cps (linear)
cps (log)
pCi/g
pCi/g
pCi/g
pCi/g
cps
cps (log)
Percent
Zero Reference = Top of Casing
Date of Last Logging Run 7/08/2004


299-E25-6 (A4796) Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
137Cs (662 keV)
cps (linear)
cps (log)
pCi/g
cps
Percent
Zero Reference = Top of Casing
Date of Last Logging Run 7/08/2004

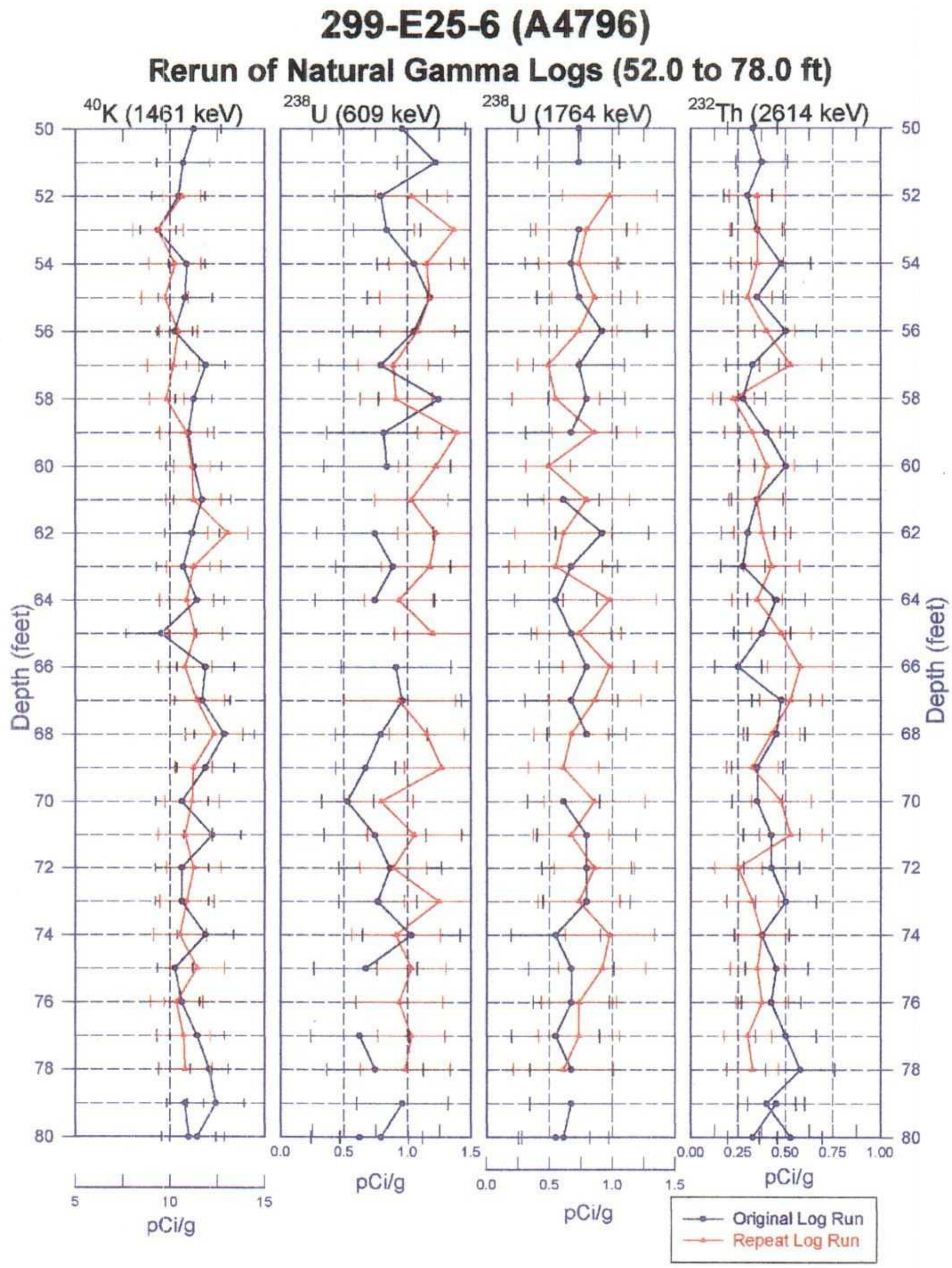
299-E25-6 (A4796) Combination Plot

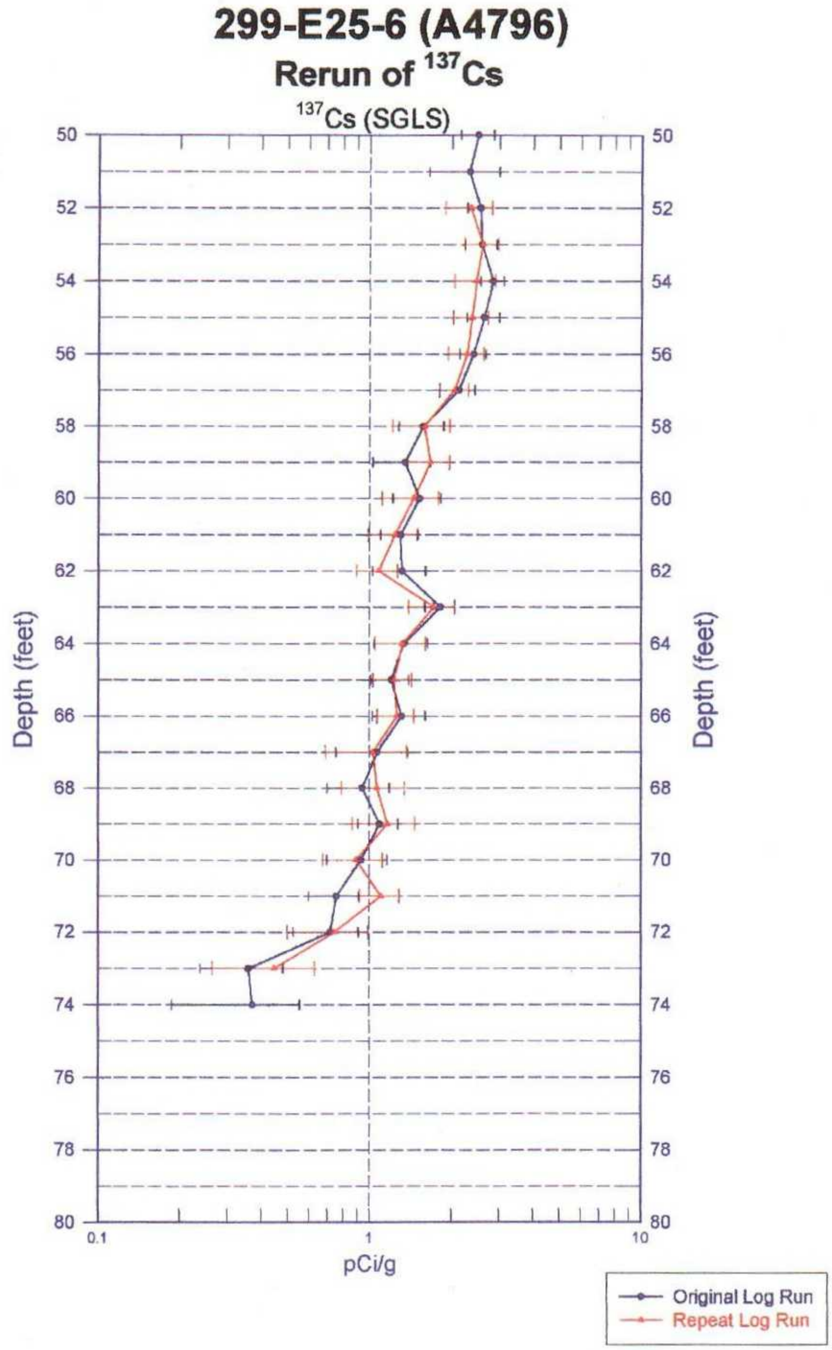



299-E25-6 (A4796)
Total Gamma & Dead Time
Total Gamma
Dead Time
Depth (feet)
cps
cps (log)
Percent
SGLS cps (linear scale)
SGLS cps (log scale)
Zero Reference = Top of Casing
Date of Last Logging Run
7/8/2004

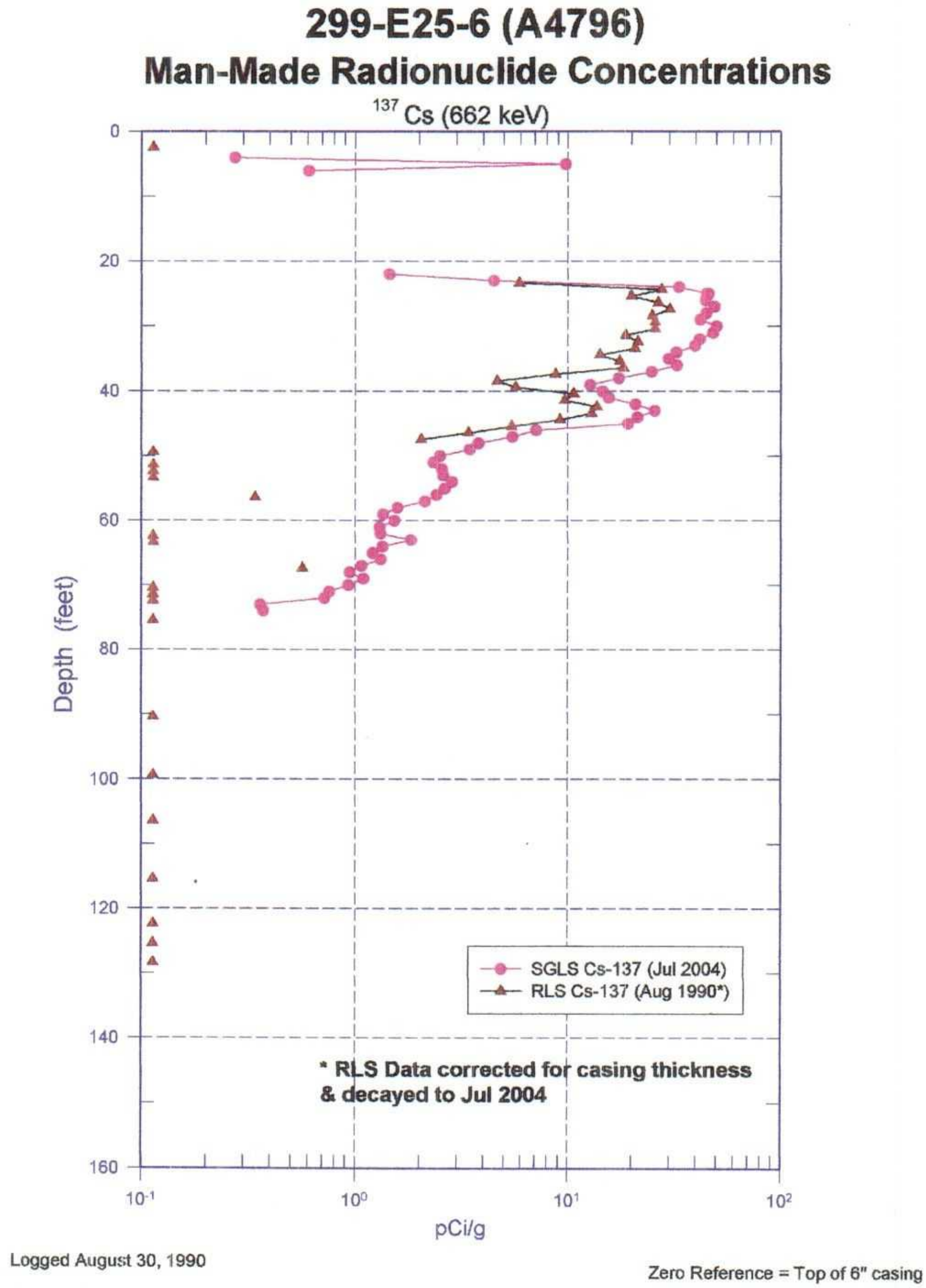


299-E25-6 (A4796)
Total Gamma & Dead Time
Total Gamma
Dead Time
Depth (feet)
cps
cps (log)
Percent
SGLS cps (linear scale)
SGLS cps (log scale)
Zero Reference = Top of Casing
Date of Last Logging Run
7/8/2004

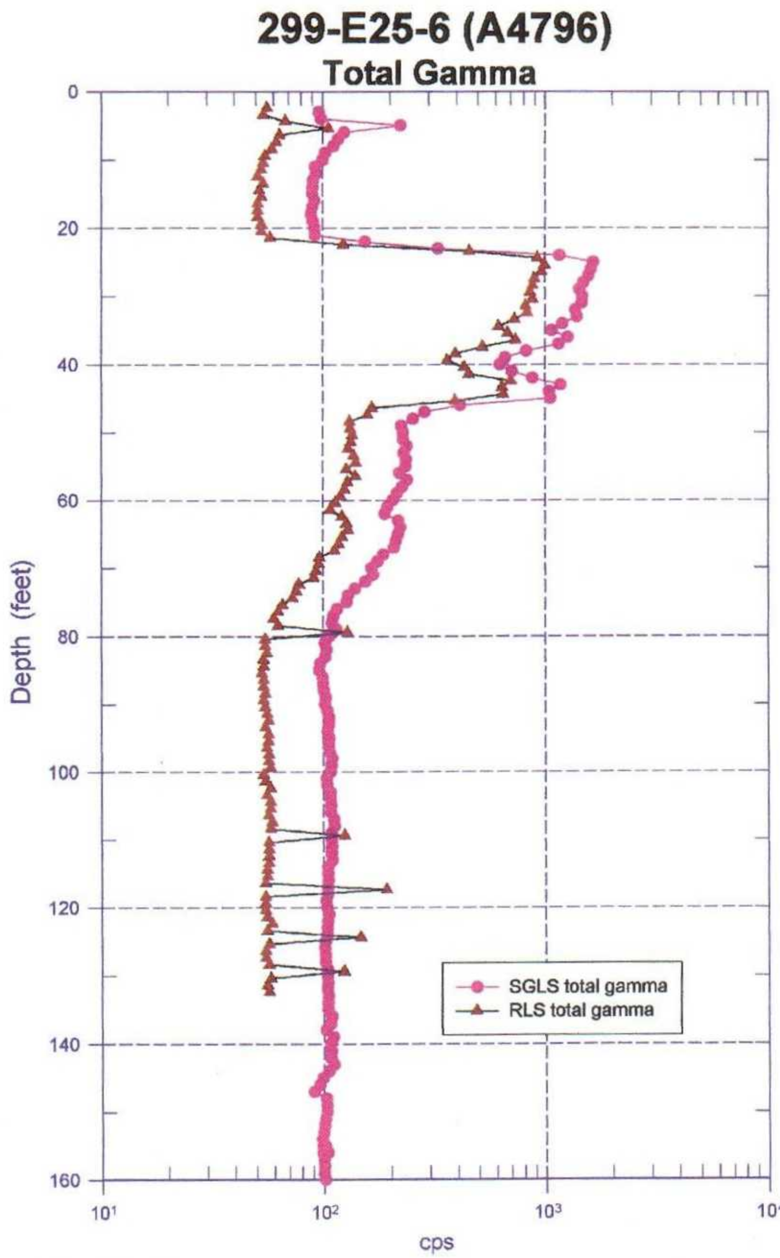

299-E25-6 (A4796)
Rerun of Natural Gamma Logs (52.0 to 78.0 ft)
40K (1461 keV)
238U (609 keV)
238U (1764 keV)
232Th (2614 keV)
Depth (feet)
pCi/g
Original Log Run
Repeat Log Run



299-E25-6 (A4796)
Rerun of 137Cs
137Cs (SGLS)
Depth (feet)
pCi/g
0.1
1
10
50
52
54
56
58
60
62
64
66
68
70
72
74
76
78
80
Original Log Run
Repeat Log Run

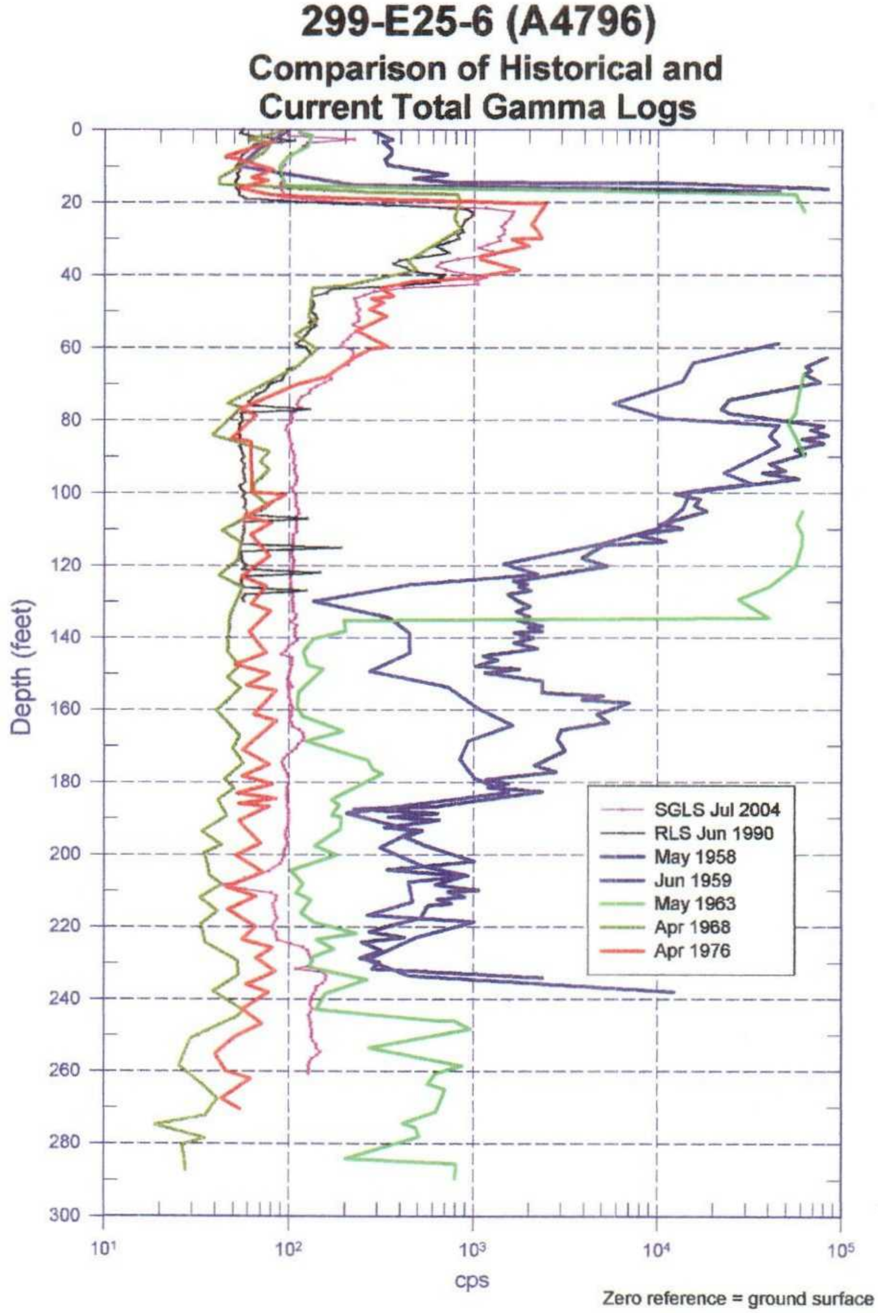


299-E25-6 (A4796)
Man-Made Radionuclide Concentrations
137 Cs (662 keV)
Depth (feet)
pCi/g
SGLS Cs-137 (Jul 2004)
RLS Cs-137 (Aug 1990*)
* RLS Data corrected for casing thickness
& decayed to Jul 2004
Logged August 30, 1990
Zero Reference = Top of 6" casing



Logged August 30, 1990

Zero Reference = Top of 6" casing



299-E25-6 (A4796)
Comparison of Historical and
Current Total Gamma Logs
Depth (feet)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
10^1
10^2
10^3
10^4
10^5
cps
SGLS Jul 2004
RLS Jun 1990
May 1958
Jun 1959
May 1963
Apr 1968
Apr 1976
Zero reference = ground surface

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299-E25-7 (A6026)
Log Data Report

Borehole Information:

Borehole:	299-E25-7 (A6026)			Site:	216-A-8 Crib	
Coordinates (WA State Plane)		GWL (ft)[1]:	260.3		GWL Date:	4/16/2004
North	East	Drill Date	TOC[2] Elevation		Total Depth (ft)	Type
136,197.87 m	575,745.61 m	May 1956	202.035 m		290	Cable Tool

Casing Information:

Casing Type	Stickup (ft)	Outer Diameter (in.)	Inside Diameter (in.)	Thickness (in.)	Top (ft)	Bottom (ft)
Welded steel	+2.6	6 5/8	6 1/8	1/4	+2.6	232.6
Welded steel	0.3	8 5/8	unknown	unknown	+0.3	290

The logging engineer measured the casing stickup using a steel tape. A caliper was used to determine the outside casing diameter. The caliper and inside casing diameter were measured using a steel tape. Measurements were rounded to the nearest 1/16 in. Casing thickness was calculated. The 8-in. casing is visible at the ground surface. Grout surrounds the casing and is in the annulus.

Borehole Notes:

Borehole coordinates, elevation, and well construction information are from measurements by Stoller field personnel, HWIS[3], and Ledgerwood (1993). Zero reference is the top of the 6-in. casing.

Logging Equipment Information:

Logging System:	Gamma 1G		Type: 35% HPGe (34TP10967A)
Calibration Date:	01/2004	Calibration Reference:	GJO-2004-597-TAC
		Logging Procedure:	MAC-HGLP 1.6.5, Rev. 0

Spectral Gamma Logging System (SGLS) Log Run Information:

Log Run	1	2	3	4	5 / Repeat
Date	4/16/03	4/19/03	4/20/03	4/21/03	4/21/03
Logging Engineer	Spatz	Spatz	Spatz	Spatz	Spatz
Start Depth (ft)	20.0	259.0	162.0	60.0	36.0
Finish Depth (ft)	3.0	161.0	59.0	19.0	19.0
Count Time (sec)	200	200	200	200	200
Live/Real	R	R	R	R	R
Shield (Y/N)	N	N	N	N	N
MSA Interval (ft)	1.0	1.0	1.0	1.0	1.0
ft/min	N/A[4]	N/A	N/A	N/A	N/A
Pre-Verification	AG070CAB	AG071CAB	AG072CAB	AG073CAB	AG073CAB
Start File	AG070000	AG071000	AG072000	AG073000	AG073042

Log Run	1	2	3	4	5 / Repeat
Finish File	AG070017	AG071098	AG072103	AG073041	AG073059
Post-Verification	AG070CAA	AG071CAA	AG072CAA	AG073CAA	AG073CAA
Depth Return Error (in.)	0	-1	-1	N/A	-1
Comments	No fine-gain adjustment.	No fine-gain adjustment.	No fine-gain adjustment.	No fine-gain adjustment.	Repeat section.

Logging Operation Notes:

Zero reference was top of the 6-in. casing. Logging was performed without the centralizer on the sonde for spectral data collected on 4/19/2004. Pre- and post-survey verification measurements for the SGLS employed the Amersham KUT (^{40}K, ^{238}U, and ^{232}Th) verifier with serial number 118. Maximum logging depth achieved was 259.0 ft, approximately 1 ft above groundwater.

Analysis Notes:

Analyst:	Sobczyk	Date:	04/26/04	Reference:	GJO-HGLP 1.6.3, Rev. 0

SGLS pre-run and post-run verification spectra were collected at the beginning and end of each day. All of the post-run verification spectra were within the acceptance criteria. The peak counts per second (cps) at the 609-keV, 1461-keV, and 2615-keV photopeaks on the post-run verification spectra as compared to the pre-run verification spectra for each day were between 3.5 percent lower and 6.9 percent higher at the end of the day.

Log spectra for the SGLS were processed in batch mode using APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Verification spectra were used to determine the energy and resolution calibration for processing the data using APTEC SUPERVISOR. Concentrations were calculated in EXCEL (source file: G1GJan04.xls), using parameters determined from analysis of recent calibration data. Zero reference was the top of the 6-in. casing. Based on Ledgerwood (1993), the casing configuration was assumed to be a string of 6-in. casing with a thickness of 1/4 in. to a log depth of 232.6 ft and a string of 8-in. casing with a thickness of 0.322 in. to total logging depth (259 ft). The 6-in. casing thickness was measured by the logging engineer. A casing thicknesss of 0.322 in. was assumed for the 8-in. casing. This thickness is the published value for ASTM schedule-40 steel pipe, a commonly used casing material at Hanford. Where more than one casing exists at a depth, the casing correction is additive (e.g., the correction for both 6-in. and 8-in. casing would be 0.25 + 0.322 = 0.572). Water and dead time corrections were not required.

Log Plot Notes:

Separate log plots are provided for gross gamma and dead time, naturally occurring radionuclides (^{40}K, ^{238}U, and ^{232}Th), and man-made radionuclides. Plots of the repeat logs versus the original logs are included. In addition, a comparison log plot of ^{137}Cs is provided to compare the data collected in 1995 by Westinghouse Hanford Company's Radionuclide Logging System (RLS) with SGLS data. For each radionuclide, the energy value of the spectral peak used for quantification is indicated. Unless otherwise noted, all radionuclides are plotted in picocuries per gram (pCi/g). The open circles indicate the minimum detectable level (MDL) for each radionuclide. Error bars on each plot represent error associated with counting statistics only and do not include errors associated with the inverse efficiency function, dead time correction, or casing correction. These errors are discussed in the calibration report. A combination plot is also included to facilitate correlation. The ^{214}Bi peak at 1764 keV was used to determine the naturally occurring ^{238}U concentrations on the combination plot.

Results and Interpretations:

^{137}Cs was the only man-made radionuclide detected in this borehole. ^{137}Cs was detected in three intervals. ^{137}Cs was detected from near the ground surface to a log depth of 9 ft. The range of concentrations was from the MDL (0.2 pCi/g) to 5.7 pCi/g. ^{137}Cs was detected at log depths between 20 and 59 ft. The range of concentrations was from 0.3 pCi/g to 3.6 pCi/g; the maximum concentration was measured at 25 ft. ^{137}Cs was detected at log depths between 225 and 236 ft. The range of concentrations was from near the MDL to 3.2 pCi/g, which was measured at 228 ft. ^{137}Cs was also detected at 209, 245, and 246 ft at concentrations near the MDL.

The concentrations of the KUT and man-made radionuclides above 225 ft are under estimated due to the effects of grout. ^{40}K concentrations are relatively low in the interval between 145 and 185 ft. Natural ^{238}U concentrations are elevated by about 1 pCi/g in the interval between 246 and 250 ft.

The behavior of the ^{238}U log suggests that radon may be present inside the borehole casing. Determination of ^{238}U is based on measurement of gamma activity at 609 and/or 1764 keV associated with ^{214}Bi, under the assumption of secular equilibrium in the decay chain. However, ^{214}Bi is also a short-term daughter of ^{222}Rn. When radon is present, ^{214}Bi will tend to "plate" onto the casing wall and will quickly reach equilibrium with ^{222}Rn. Because the additional ^{214}Bi resulting from radon is on the inside of the casing, the effect of the casing correction is to amplify the 609 photopeak relative to the 1764 photopeak. (The magnitude of the casing correction factor decreases with increasing energy, but gamma rays originating inside the casing are not attenuated.) This effect is seen on logging run 2 (259 to 161 ft). The effects of radon appear to be minimal in the other log runs. The reason for variations in radon content between log runs on successive days is not known. Variations in radon content in boreholes are probably related to variations in surface weather conditions. Radon daughters such as ^{214}Bi may also "plate" onto the sonde itself. When this occurs, there is a gradual increase in total counts as well as photopeak counts associated with ^{214}Bi and ^{214}Pb.

The presence of radon is not an indication of man-made contamination: it is derived from decay of naturally occurring uranium. As a gas, radon moves easily in the subsurface, and concentrations of radon and its associated progeny can change quickly.

The plots of the repeat logs demonstrate reasonable repeatability of the SGLS data for the natural radionuclides (609, 1461, 1764, and 2614 keV) and ^{137}Cs.

Gross gamma logs from Additon et al. (1977) (attached) indicate that the sediments surrounding this borehole contained significant amounts of man-made gamma radiation from 1958 through at least 1976. The logs from 1958, 1959, and 1963 indicate gamma-emitting contamination at or near groundwater. The logs from 2/19/58, 6/1/59, and 5/14/63 appear to detect relatively high gamma activity in the interval from 16 ft (5 m) to 131 ft (40 m). The logs from 4/25/68 and 4/30/76 appear to detect elevated gamma activity near the surface and in the interval from 19 ft (6 m) to 43 ft (13 m). Comparison of these gross gamma logs indicates that a major contamination event occurred prior 1958. The SGLS detected ^{137}Cs in all of the contaminated intervals, which had elevated gamma in the late 1950s.

A comparison log plot of ^{137}Cs data collected in 1995 by Westinghouse Hanford Company (WHC) and in 2004 by Stoller is included. The WHC concentration data for ^{137}Cs are decayed to the date of the SGLS logging event in April 2004. There is a 1990 RLS log run to a depth of 103 ft; however, little ^{137}Cs was reported in the interval between the surface and 59 ft. This logging run is described as a "system shake down test". The reported results from the 1990 log run are considered unreliable because the tool was not calibrated until a year after the log run. There may be a depth registration discrepancy between the 1995 and 2004 log runs below 200 ft. Taking into account the differences in depth registration, the apparent ^{137}Cs concentrations show good agreement between the logging systems. Since 1995, ^{137}Cs activities have probably decreased as predicted by radioactive decay.

References:

Additon, M.K., K.R. Fecht, T.L. Jones, and G.V. Last, 1978, *Scintillation Probe Profiles From 200 East Area Crib Monitoring Wells*, RHO-LD-28, Rockwell Hanford Operations, Richland, Washington.

Ledgerwood, R.K., 1993, *Summaries of Well Construction Data and Field Observations for Existing 200-East Resource Protection Wells*, WHC-SD-ER-TI-007, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

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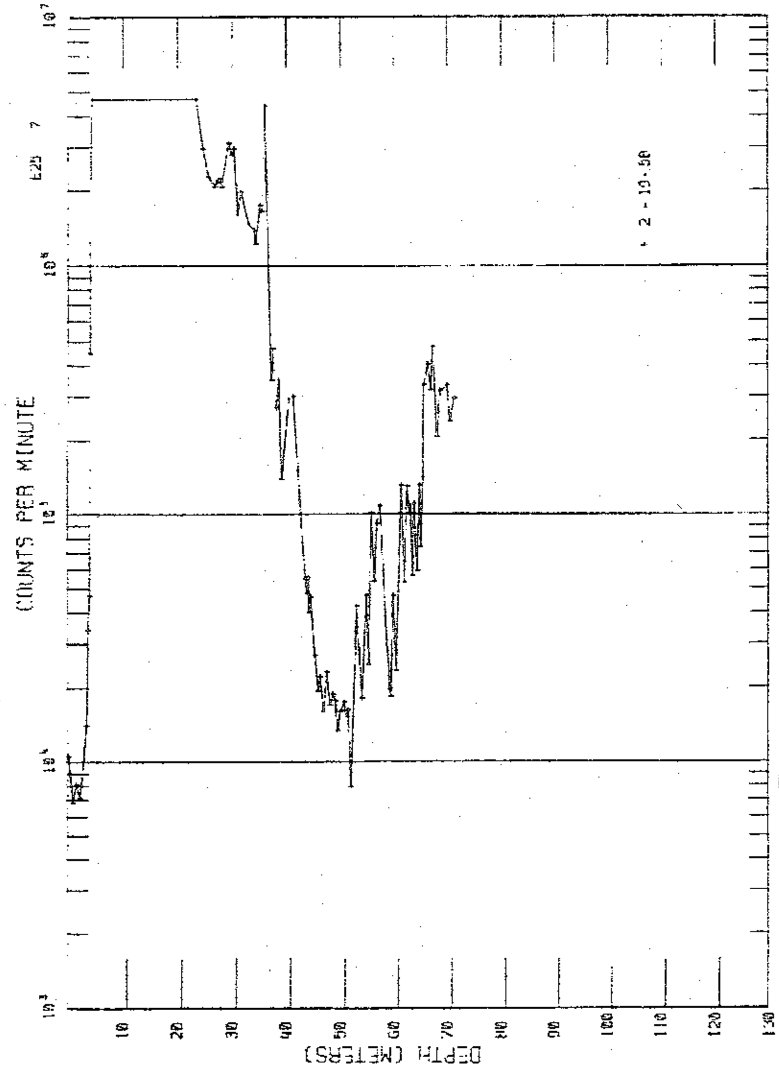
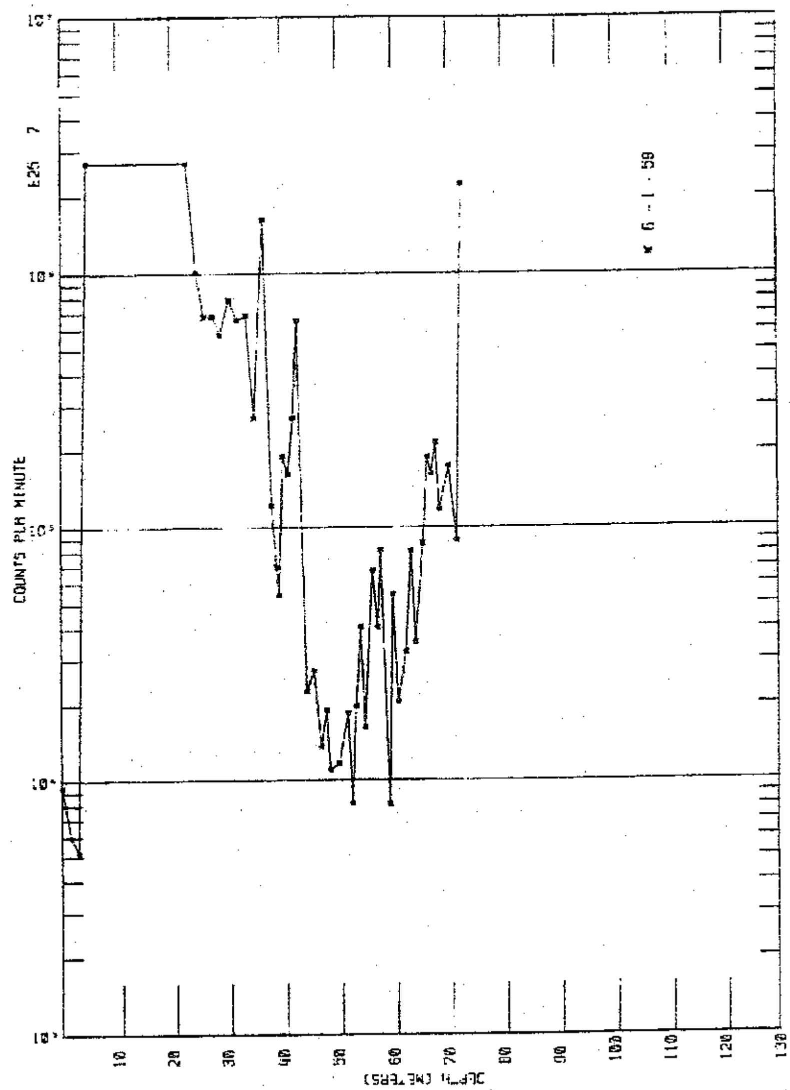
[1] GWL – groundwater level
[2] TOC – top of casing
[3] HWIS – Hanford Well Information System
[4] N/A – not applicable



from Additon et al. (1978)

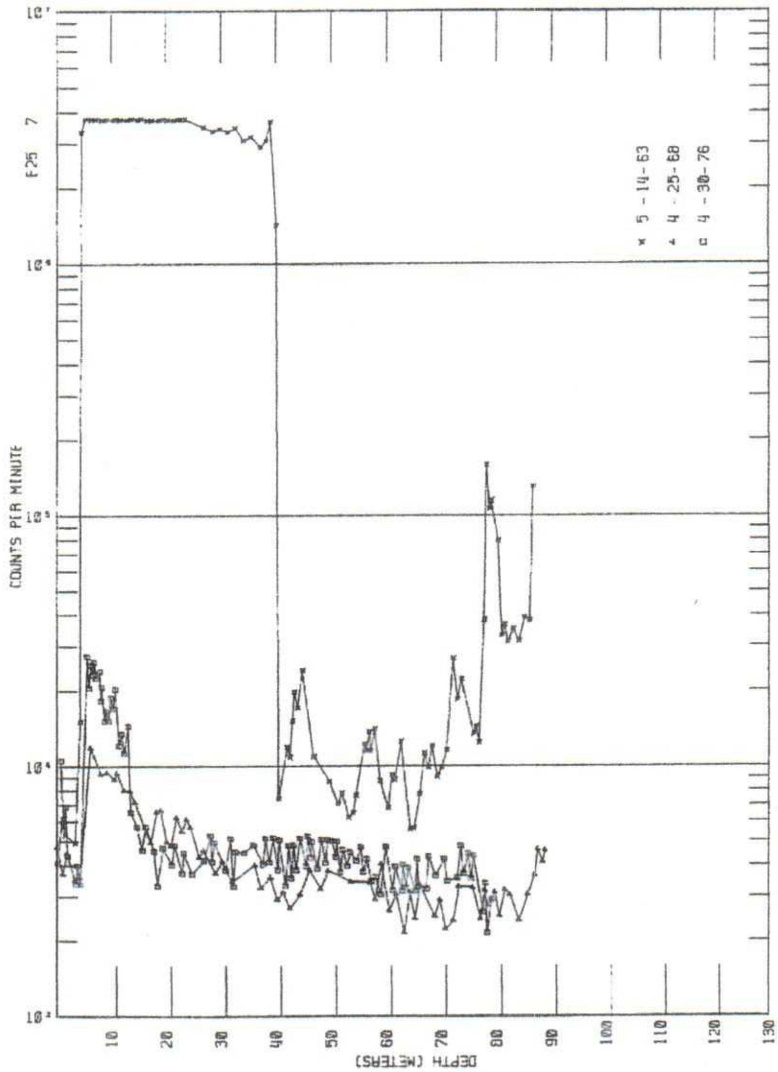
Scintillation Probe Profiles for Borehole 299-E25-7, Logged on 2/19/58

Page 5



from Additon et al. (1978)

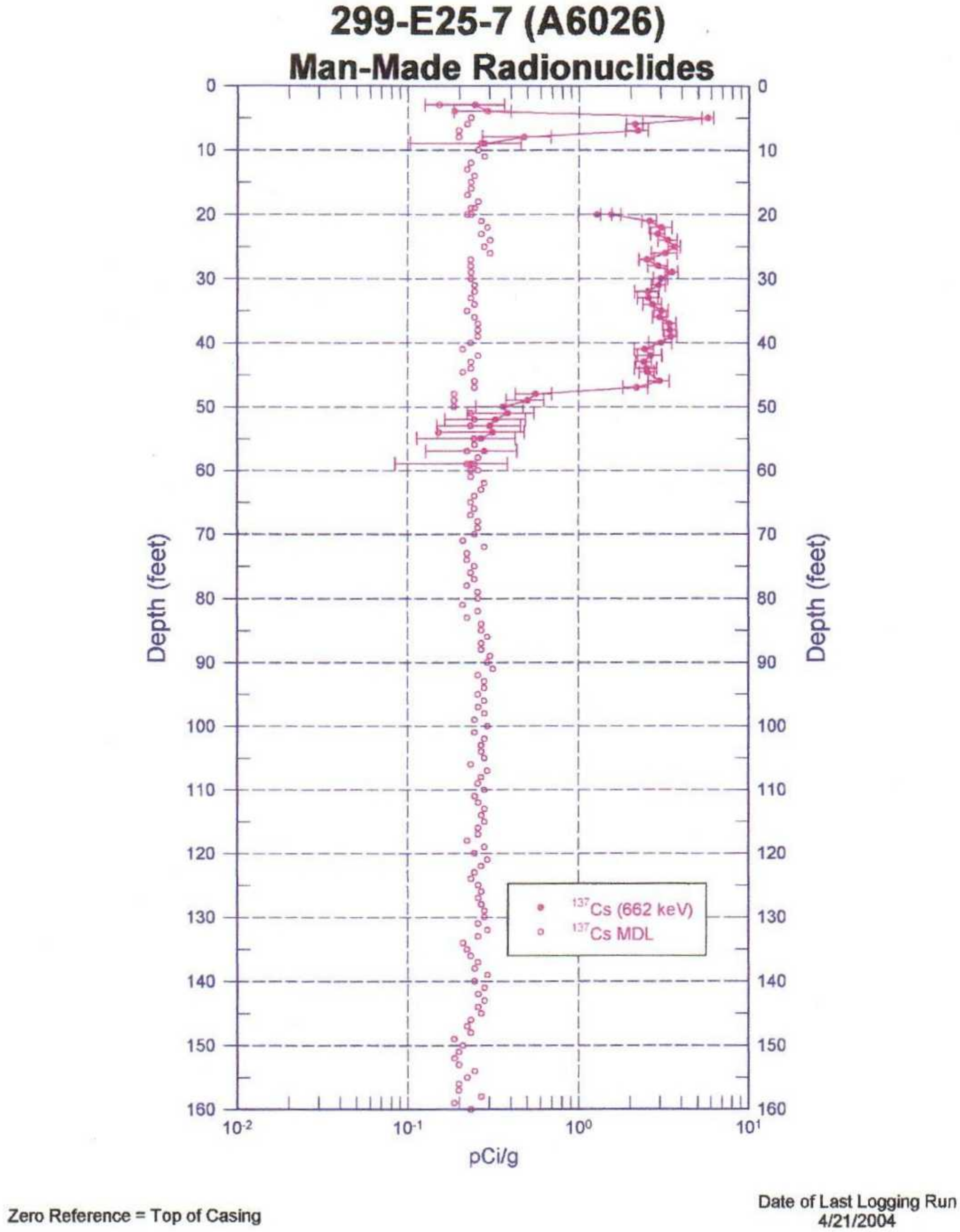
Scintillation Probe Profile for Borehole 299-E25-7, Logged on 6/1/59

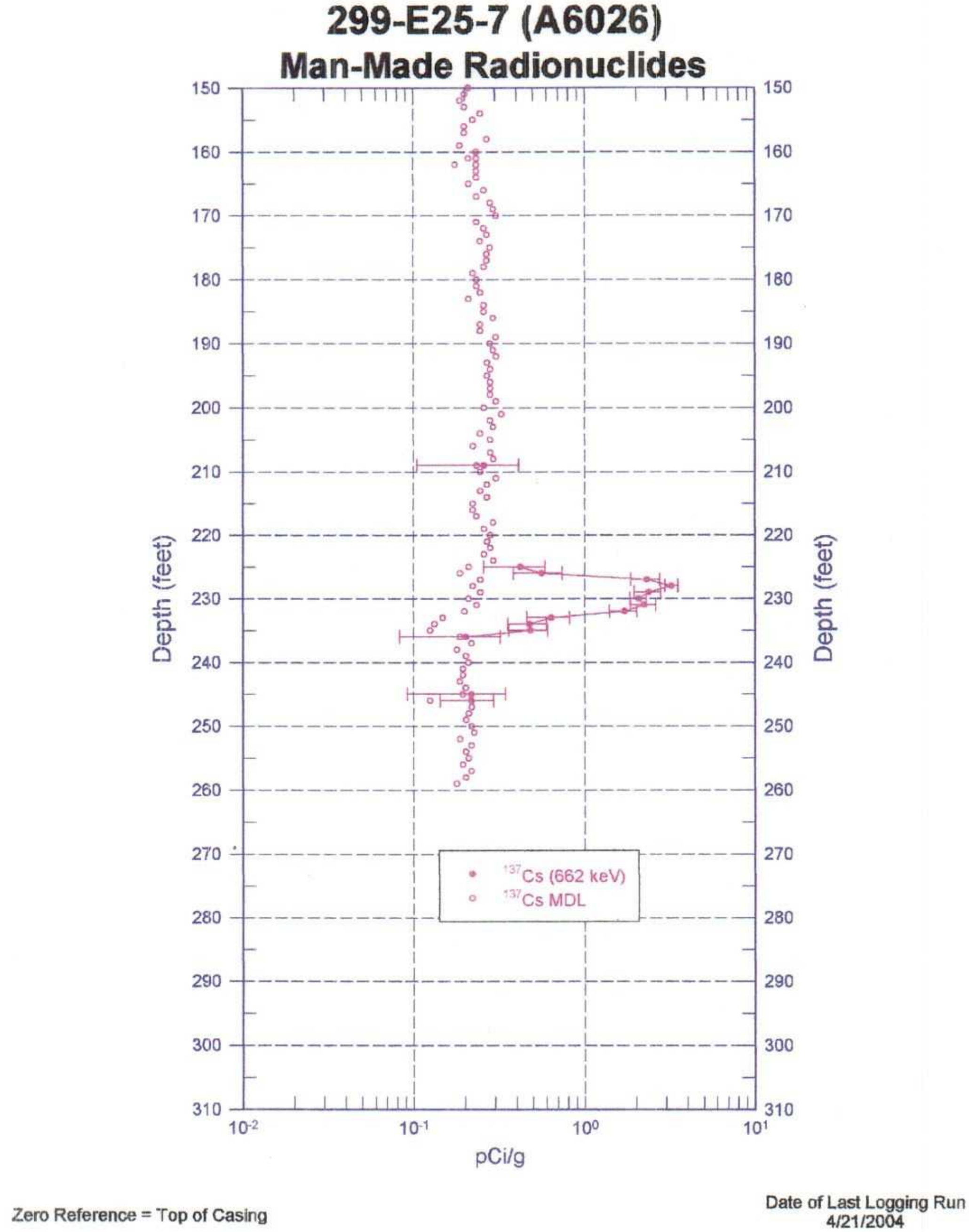


from Additon et al. (1978)

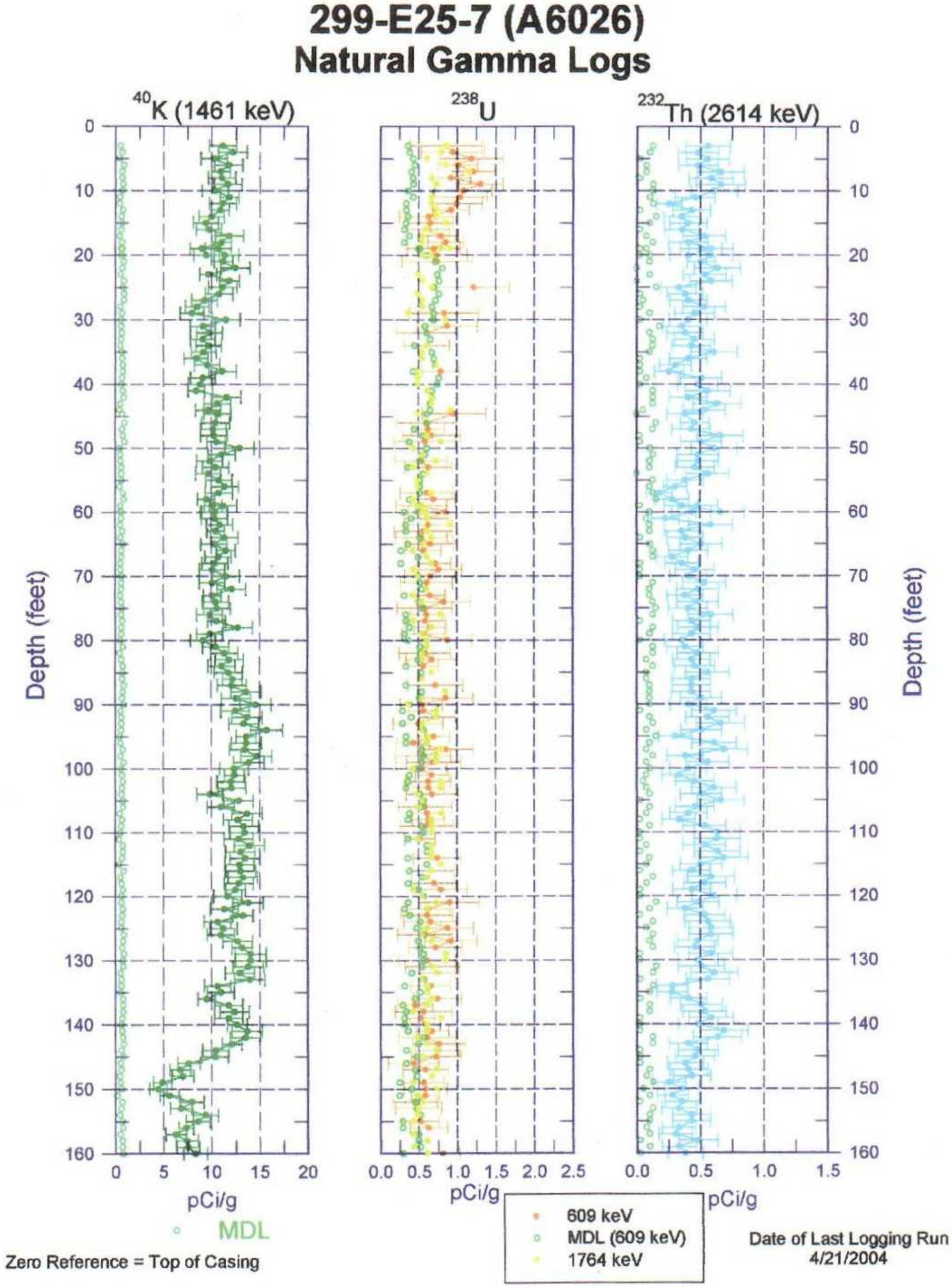
Scintillation Probe Profiles for Borehole 299-E25-7, Logged on 5/14/63, 4/25/68, and 4/30/76

Page 7

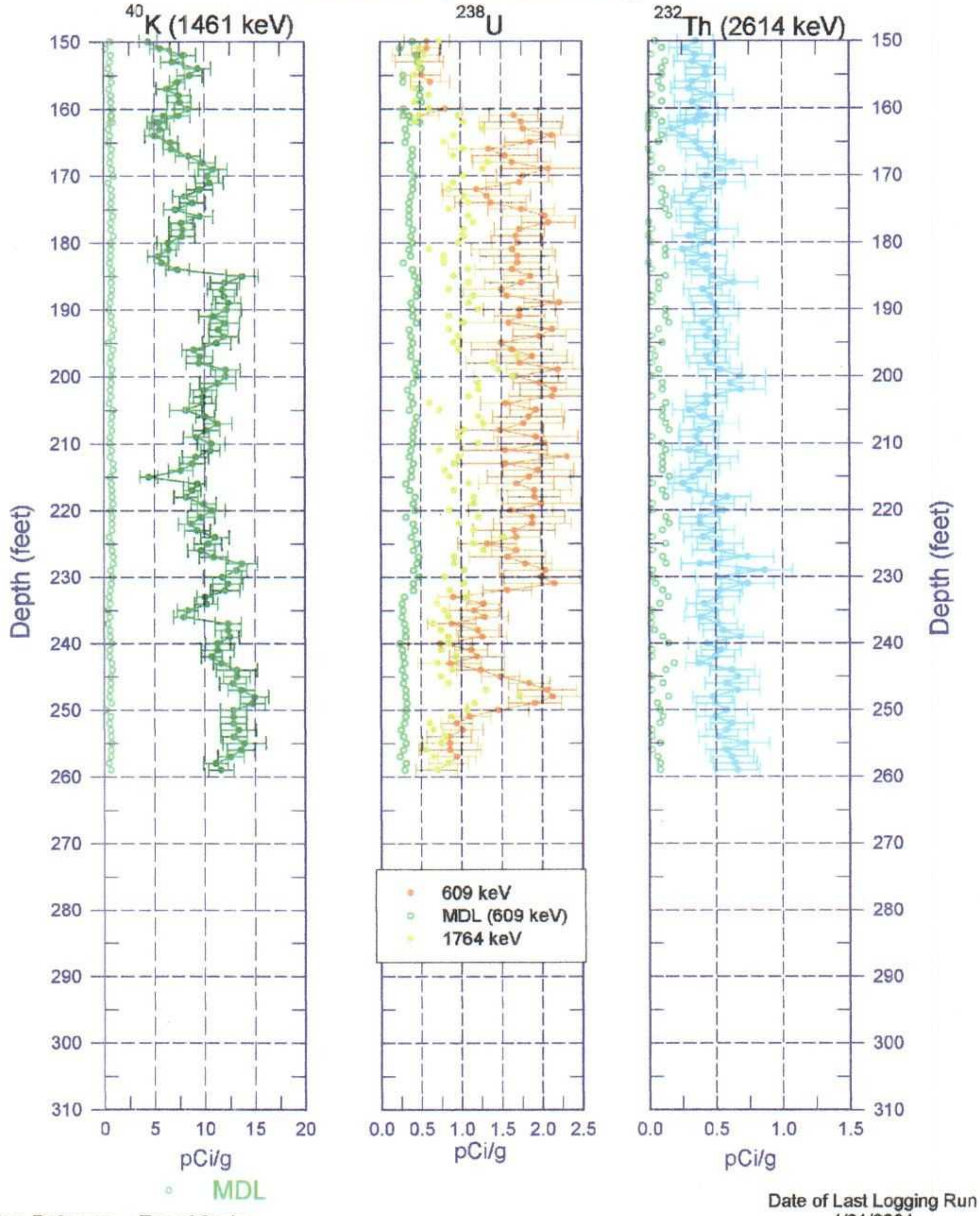

299-E25-7 (A6026)
Man-Made Radionuclides
Depth (feet)
pCi/g
^{137}Cs (662 keV)
^{137}Cs MDL
Zero Reference = Top of Casing
Date of Last Logging Run
4/21/2004



299-E25-7 (A6026)
Man-Made Radionuclides
Depth (feet)
pCi/g
^{137}Cs (662 keV)
^{137}Cs MDL
Zero Reference = Top of Casing
Date of Last Logging Run
4/21/2004

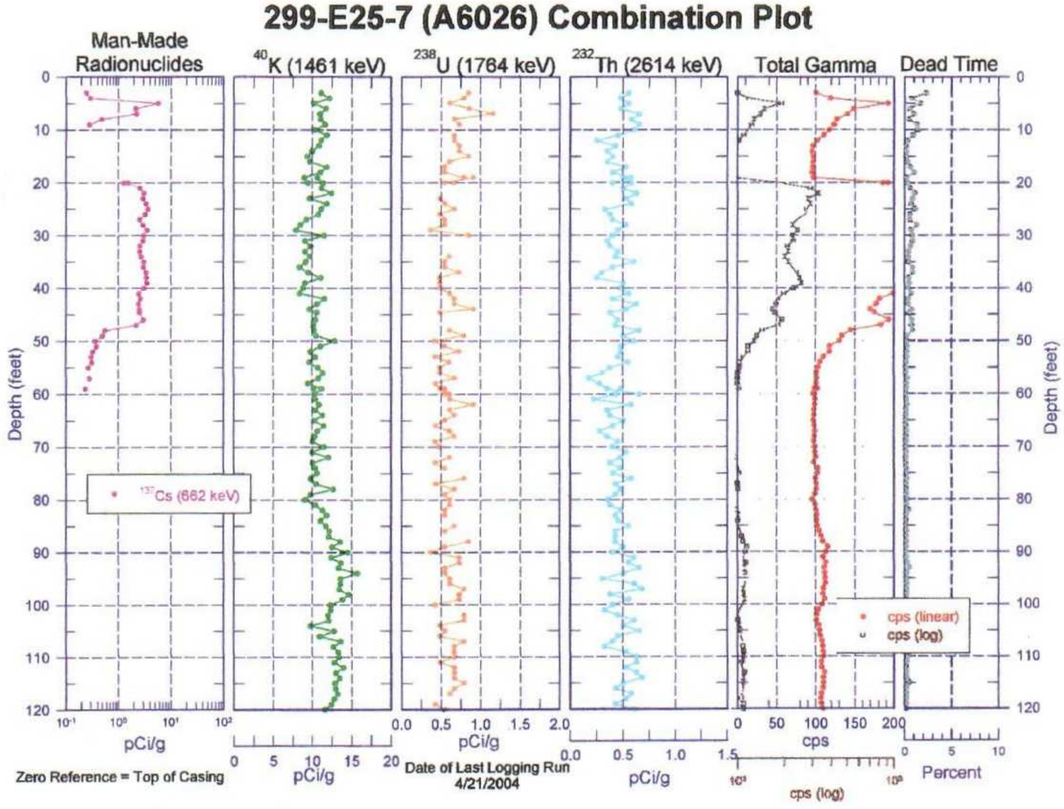

299-E25-7 (A6026)
Natural Gamma Logs
40K (1461 keV)
238U
232Th (2614 keV)
Depth (feet)
pCi/g
MDL
609 keV
MDL (609 keV)
1764 keV
Zero Reference = Top of Casing
Date of Last Logging Run
4/21/2004

299-E25-7 (A6026)
Natural Gamma Logs

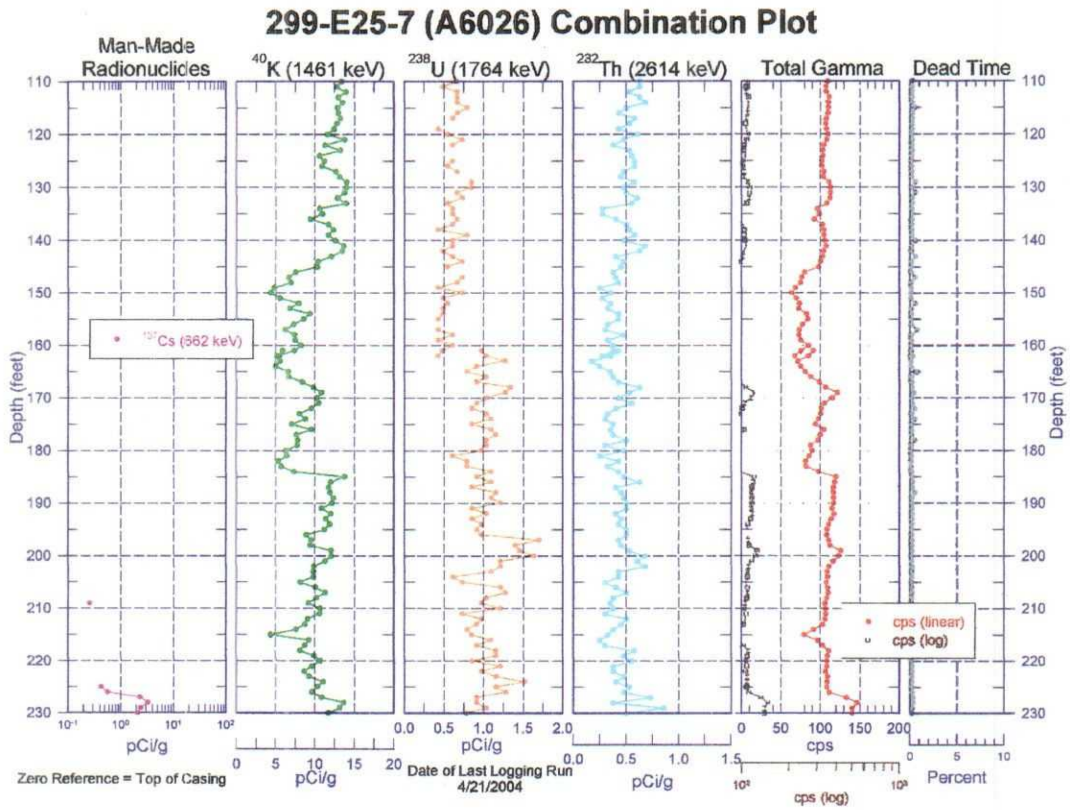


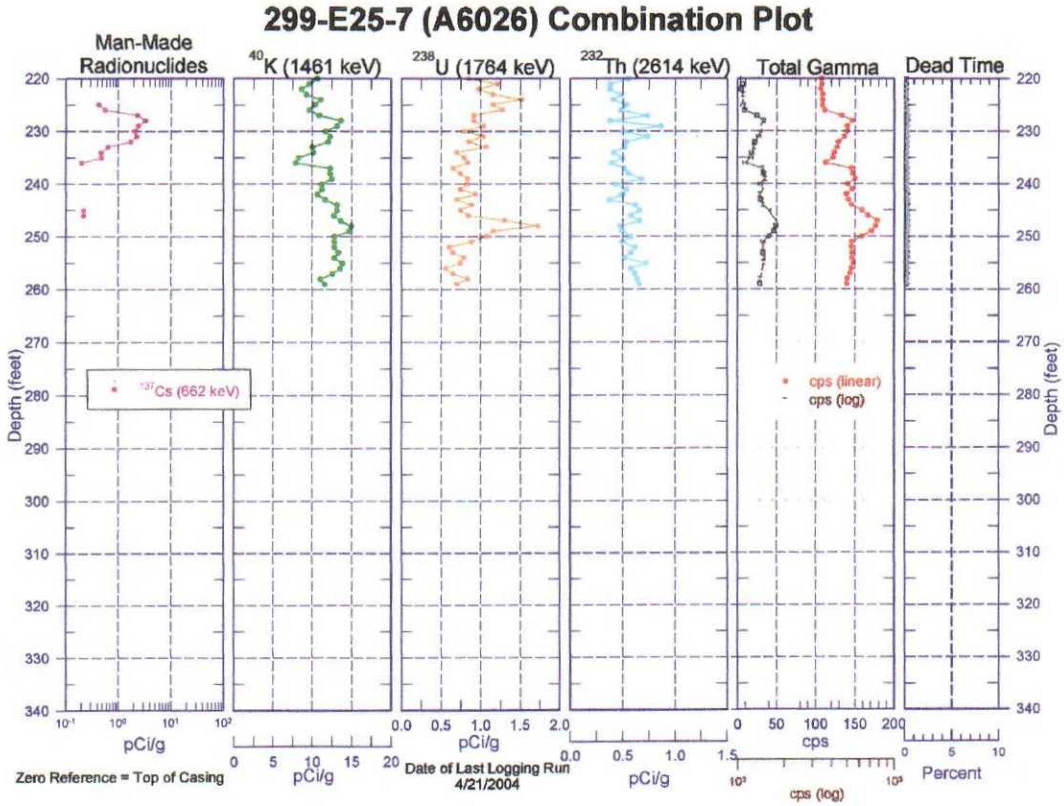
Zero Reference = Top of Casing

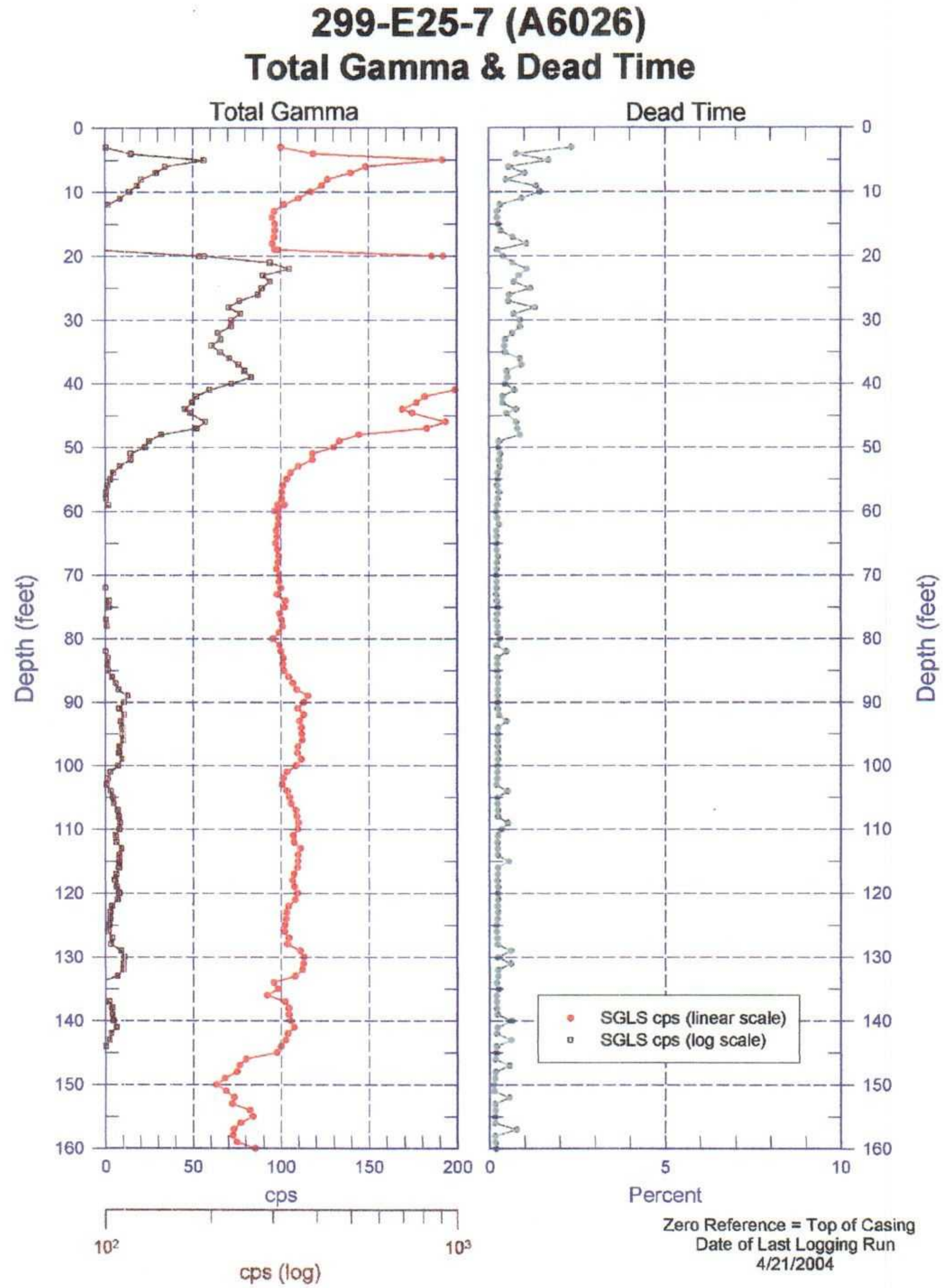
Date of Last Logging Run
4/21/2004



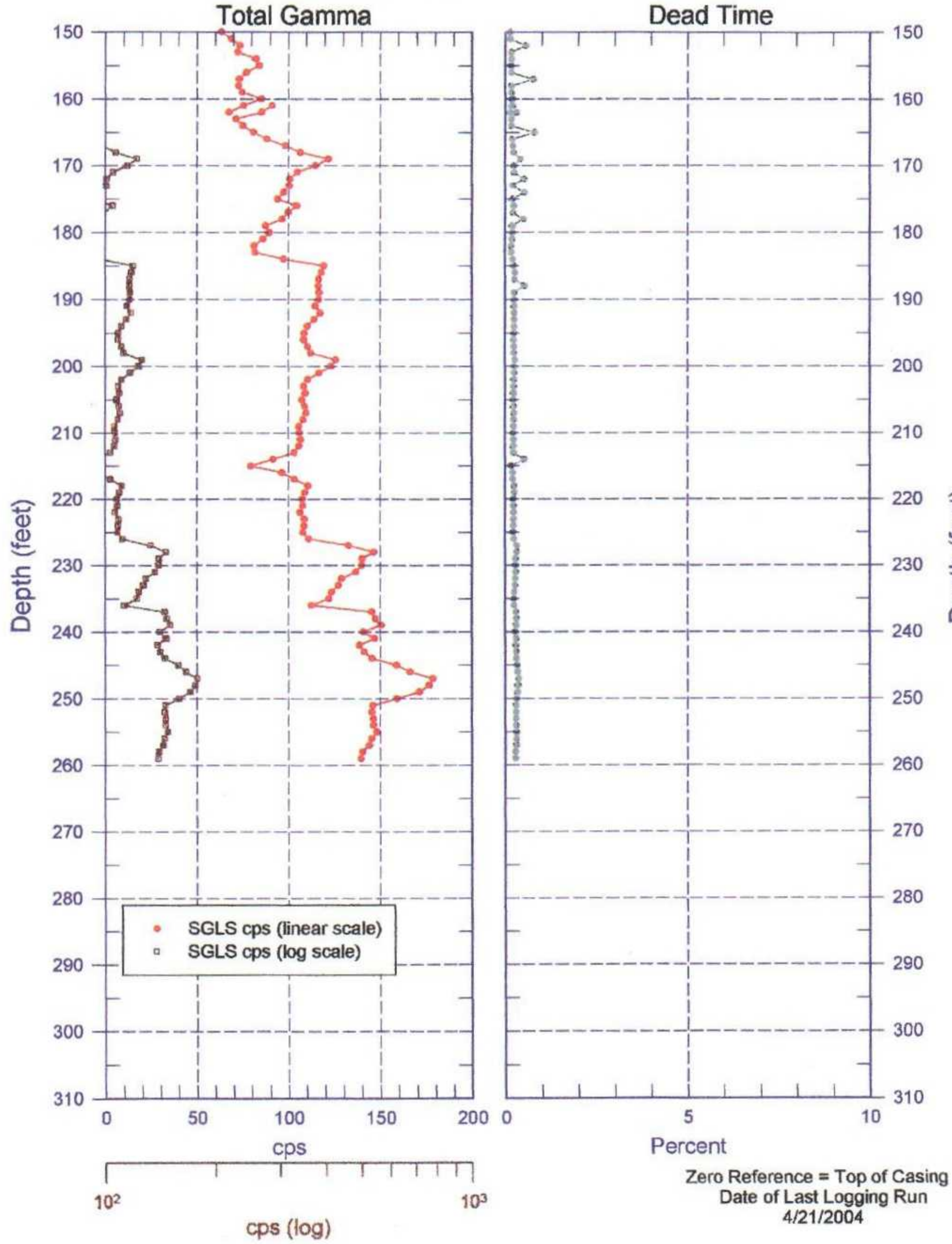
299-E25-7 (A6026) Combination Plot
Man-Made Radionuclides
⁴⁰K (1461 keV)
²³⁸U (1764 keV)
²³²Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
¹³⁷Cs (662 keV)
cps (linear)
cps (log)
pCi/g
Zero Reference = Top of Casing
Date of Last Logging Run 4/21/2004
cps
cps (log)
Percent

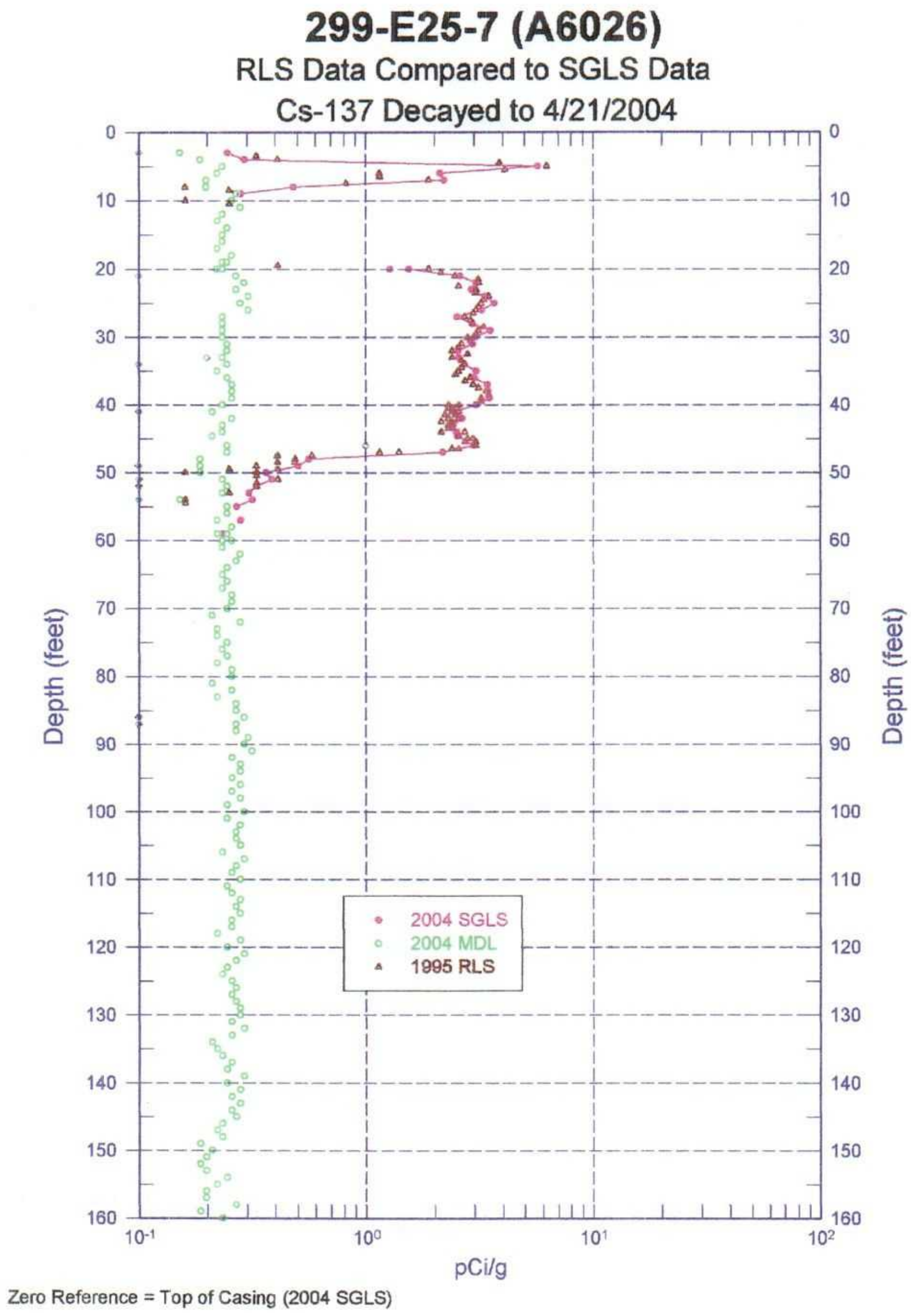

299-E25-7 (A6026) Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
137Cs (662 keV)
cps (linear)
cps (log)
pCi/g
cps
Percent
Zero Reference = Top of Casing
Date of Last Logging Run 4/21/2004

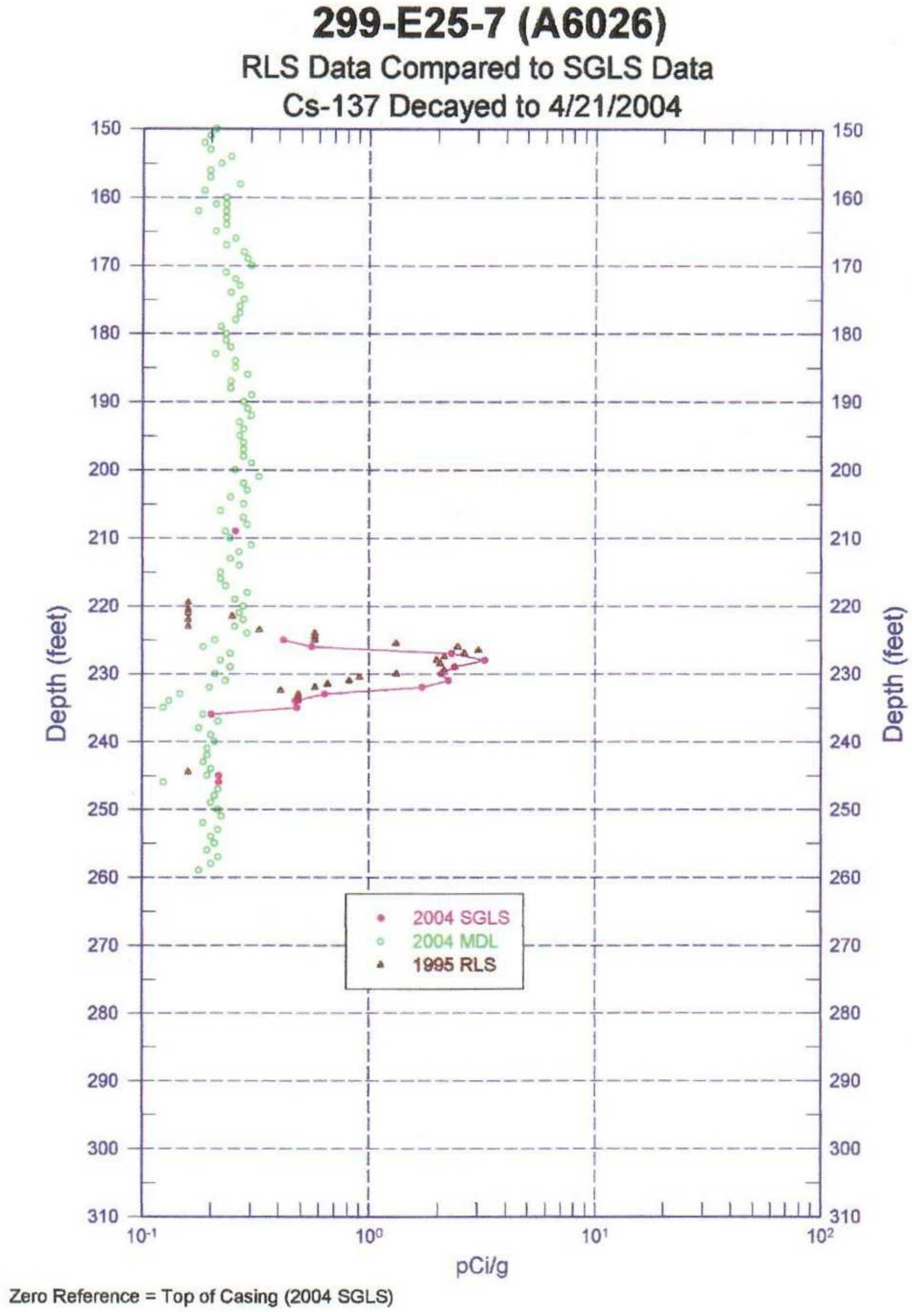

299-E25-7 (A6026) Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
137Cs (662 keV)
cps (linear)
cps (log)
pCi/g
Zero Reference = Top of Casing
Date of Last Logging Run 4/21/2004
cps
cps (log)
Percent


299-E25-7 (A6026)
Total Gamma & Dead Time
Total Gamma
Dead Time
Depth (feet)
cps
cps (log)
Percent
SGLS cps (linear scale)
SGLS cps (log scale)
Zero Reference = Top of Casing
Date of Last Logging Run
4/21/2004

299-E25-7 (A6026)
Total Gamma & Dead Time



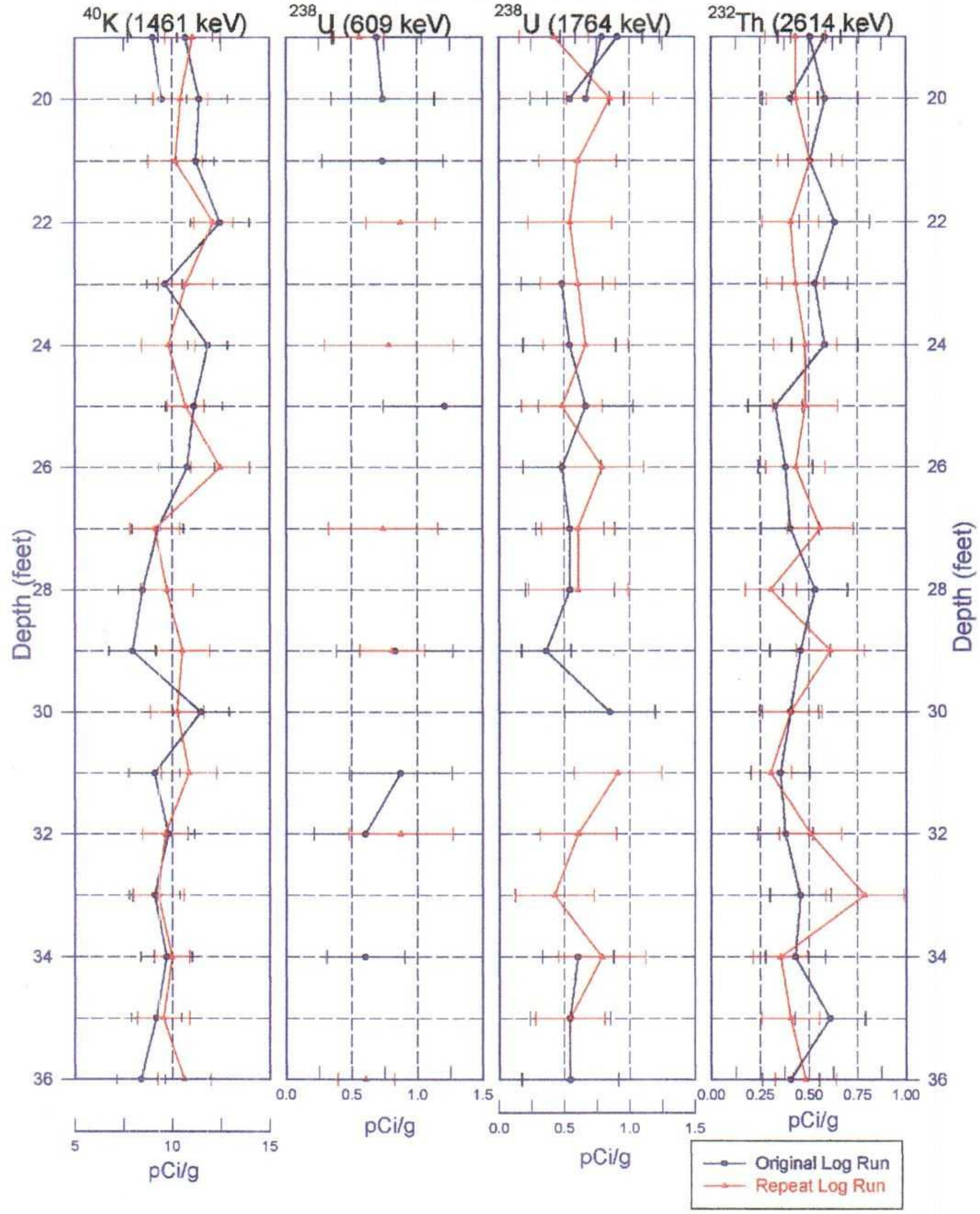

299-E25-7 (A6026)
RLS Data Compared to SGLS Data
Cs-137 Decayed to 4/21/2004
Depth (feet)
pCi/g
2004 SGLS
2004 MDL
1995 RLS
Zero Reference = Top of Casing (2004 SGLS)

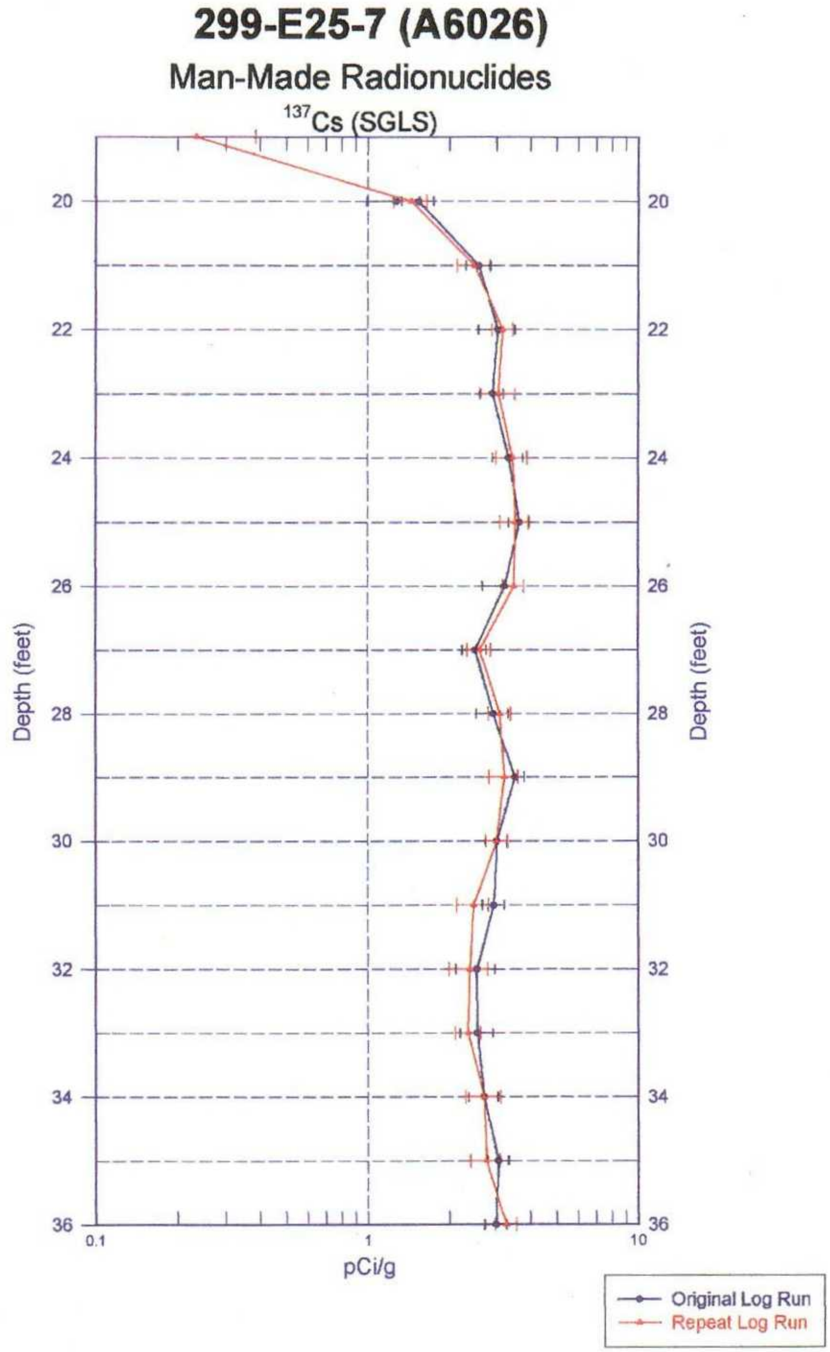


299-E25-7 (A6026)
RLS Data Compared to SGLS Data
Cs-137 Decayed to 4/21/2004
Depth (feet)
pCi/g
2004 SGLS
2004 MDL
1995 RLS
Zero Reference = Top of Casing (2004 SGLS)

299-E25-7 (A6026)

Rerun of Natural Gamma Logs (36.0 to 19.0 ft)





299-E25-7 (A6026)
Man-Made Radionuclides
^{137}Cs (SGLS)
Depth (feet)
20
22
24
26
28
30
32
34
36
0.1
1
10
pCi/g
Original Log Run
Repeat Log Run

Hanford Office

DOE-EM/GJ689-2004

299-E25-08 (A6027)
Log Data Report

Borehole Information:

Borehole:	299-E25-08 (A6027)		Site:	216-A-8 Crib	
Coordinates (WA State Plane)		GWL (ft)[1]:	263.2	GWL Date:	06/23/04
North	East	Drill Date	TOC[2] Elevation	Total Depth (ft)	Type
136,190.035 m	575,814.825 m	May 1956	202.476 m	290	Cable Tool

Casing Information:

Casing Type	Stickup (ft)	Outer Diameter (in.)	Inside Diameter (in.)	Thickness (in.)	Top (ft)	Bottom (ft)
Welded steel	+2.3	6 5/8	6 1/8	1/4	+2.3	237
Welded steel	0	unknown	unknown	unknown	0	290

The logging engineer measured the casing stickup using a steel tape. A caliper was used to determine the outside casing diameter. The caliper and inside casing diameter were measured using a steel tape. Measurements were rounded to the nearest 1/16 in. Casing thickness was calculated. The 8-in. casing is not visible at the ground surface.

Borehole Notes:

Borehole coordinates, elevation, and well construction information are from measurements by Stoller field personnel, HWIS[3], and Ledgerwood (1993). Zero reference is the top of the 6-in. casing.

Logging Equipment Information:

Logging System:	Gamma 2A		Type: 35% HPGe (34TP20893A)
Calibration Date:	03/04	Calibration Reference:	DOE-EM/GJ642-2004
		Logging Procedure:	MAC-HGLP 1.6.5, Rev. 0

Spectral Gamma Logging System (SGLS) Log Run Information:

Log Run	1	2	3	4	5 / Repeat
Date	06/21/04	06/22/04	06/23/04	06/24/04	06/25/04
Logging Engineer	Spatz	Spatz	Spatz	Spatz	Spatz
Start Depth (ft)	36.0	90.0	166.0	262.0	53.0
Finish Depth (ft)	3.0	35.0	89.0	165.0	19.0
Count Time (sec)	200	200	200	200	200
Live/Real	R	R	R	R	R
Shield (Y/N)	N	N	N	N	N
MSA Interval (ft)	1.0	1.0	1.0	1.0	1.0
ft/min	N/A[4]	N/A	N/A	N/A	N/A
Pre-Verification	BA349CAB	BA350CAB	BA351CAB	BA352CAB	BA353CAB
Start File	BA349000	BA350000	BA351000	BA352000	BA353000

Log Run	1	2	3	4	5 / Repeat
Finish File	BA349033	BA350055	BA351077	BA352097	BA353034
Post-Verification	BA349CAA	BA350CAA	BA351CAA	BA352CAA	BA353CAA
Depth Return Error (in.)	0	0	0	+ 1	0
Comments	Fine gain adjustment after files: -003, -013, -016, and -030.	Fine gain adjustment after files: -016 and -035.	Fine gain adjustment after files: -034, -048, -057, -067, and -073.	Fine gain adjustment after files: -042, -062, -077, and -088.	No fine gain adjustment.

Logging Operation Notes:

Zero reference was top of the 6-in. casing. Logging was performed without the centralizer on the sonde for spectral data collected on 06/24/04. Pre- and post-survey verification measurements for the SGLS employed the Amersham KUT (^{40}K, ^{238}U, and ^{232}Th) verifier with serial number 082. Maximum logging depth achieved was 262.0 ft, approximately 1 ft above groundwater.

Analysis Notes:

Analyst:	Henwood	Date:	06/29/04	Reference:	GJO-HGLP 1.6.3, Rev. 0

SGLS pre-run and post-run verification spectra were collected at the beginning and end of each day. All of the verification spectra were within the acceptance criteria.

Log spectra for the SGLS were processed in batch mode using APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Verification spectra were used to determine the energy and resolution calibration for processing the data using APTEC SUPERVISOR. Concentrations were calculated in EXCEL (source file: G2AMAR04.xls), using parameters determined from analysis of recent calibration data. Zero reference was the top of the 6-in. casing. Based on Ledgerwood (1993), the casing configuration was assumed to be a string of 6-in. casing with a thickness of 1/4 in. to a log depth of 237 ft and a string of 8-in. casing with a thickness of 0.322 in. to the depth of 262 ft. The 6-in. casing thickness was measured by the logging engineer. A casing thicknesss of 0.322 in. was assumed for the 8-in. casing. This thickness is the published value for ASTM schedule-40 steel pipe, a commonly used casing material at Hanford. Where more than one casing exists at a depth, the casing correction is additive (e.g., the correction for both 6-in. and 8-in. casing would be 0.25 + 0.322 = 0.572). Water and dead time corrections were not required.

Log Plot Notes:

Separate log plots are provided for gross gamma and dead time, naturally occurring radionuclides (^{40}K, ^{238}U, and ^{232}Th), and man-made radionuclides. Plots of the repeat logs versus the original logs are included. For each radionuclide, the energy value of the spectral peak used for quantification is indicated. Unless otherwise noted, all radionuclides are plotted in picocuries per gram (pCi/g). The open circles indicate the minimum detectable level (MDL) for each radionuclide. Error bars on each plot represent error associated with counting statistics only and do not include errors associated with the inverse efficiency function, dead time correction, or casing correction. These errors are discussed in the calibration report. A combination plot is also included to facilitate correlation. The ^{214}Bi peak at 1764 keV was used to determine the naturally occurring ^{238}U concentrations on the combination plot.

Results and Interpretations:

^{137}Cs was the only man-made radionuclide detected in this borehole. ^{137}Cs was detected at 5 ft, at approximately 22 ft, at a few sporadic locations throughout the borehole, and between 234 and 240 ft. The range of concentrations was from the MDL (0.2 pCi/g) to 4.5 pCi/g, which was measured at 5 ft. The ^{137}Cs detected at log depths between 234 and 240 ft is located at a depth interval approximately 22 ft above the current groundwater level. It is possible that a groundwater mound existed in the area in the past and the ^{137}Cs is a remnant of contaminated groundwater. The range of concentrations in the interval between 234 and 240 ft was from near the MDL to 2.5 pCi/g, which was measured at 237 ft.

The concentrations of the KUT above 240 ft appear to be underestimated due to the effects of double casing and grout.

The behavior of the ^{238}U log suggests that radon may be present inside the borehole casing. Determination of ^{238}U is based on measurement of gamma activity at 609 and/or 1764 keV associated with ^{214}Bi, under the assumption of secular equilibrium in the decay chain. However, ^{214}Bi is also a short-term daughter of ^{222}Rn. When radon is present, ^{214}Bi will tend to "plate" onto the casing wall and will quickly reach equilibrium with ^{222}Rn. Because the additional ^{214}Bi resulting from radon is on the inside of the casing, the effect of the casing correction is to amplify the 609 photopeak relative to the 1764 photopeak. (The magnitude of the casing correction factor decreases with increasing energy, but gamma rays originating inside the casing are not attenuated.) This effect is observed in log data acquired during logging runs 1 and 2 (3 to 90 ft). The effects of radon appear to be minimal in the other log runs. The reason for variations in radon content between log runs on successive days is not known. Variations in radon content in boreholes are probably related to variations in surface weather conditions. Radon daughters such as ^{214}Bi may also "plate" onto the sonde itself. When this occurs, there is a gradual increase in total counts as well as photopeak counts associated with ^{214}Bi and ^{214}Pb.

The presence of radon is not an indication of man-made contamination; it is derived from decay of naturally occurring uranium. As a gas, radon moves easily in the subsurface, and concentrations of radon and its associated progeny can change quickly.

The plots of the repeat logs demonstrate reasonable repeatability of the SGLS data for the natural radionuclides (609, 1461, 1764, and 2614 keV energy levels).

Gross gamma logs from Additon et al. (1977) (attached) indicate that the sediments surrounding this borehole contained significant amounts of man-made gamma radiation extending to groundwater from 1958 through at least 1963. By 1976 most of the gamma activity in the vadose zone had decayed away.

References:

Additon, M.K., K.R. Fecht, T.L. Jones, and G.V. Last, 1978. *Scintillation Probe Profiles From 200 East Area Crib Monitoring Wells*, RHO-LD-28, Rockwell Hanford Operations, Richland, Washington.

Ledgerwood, R.K., 1993. *Summaries of Well Construction Data and Field Observations for Existing 200-East Resource Protection Wells*, WHC-SD-ER-TI-007, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

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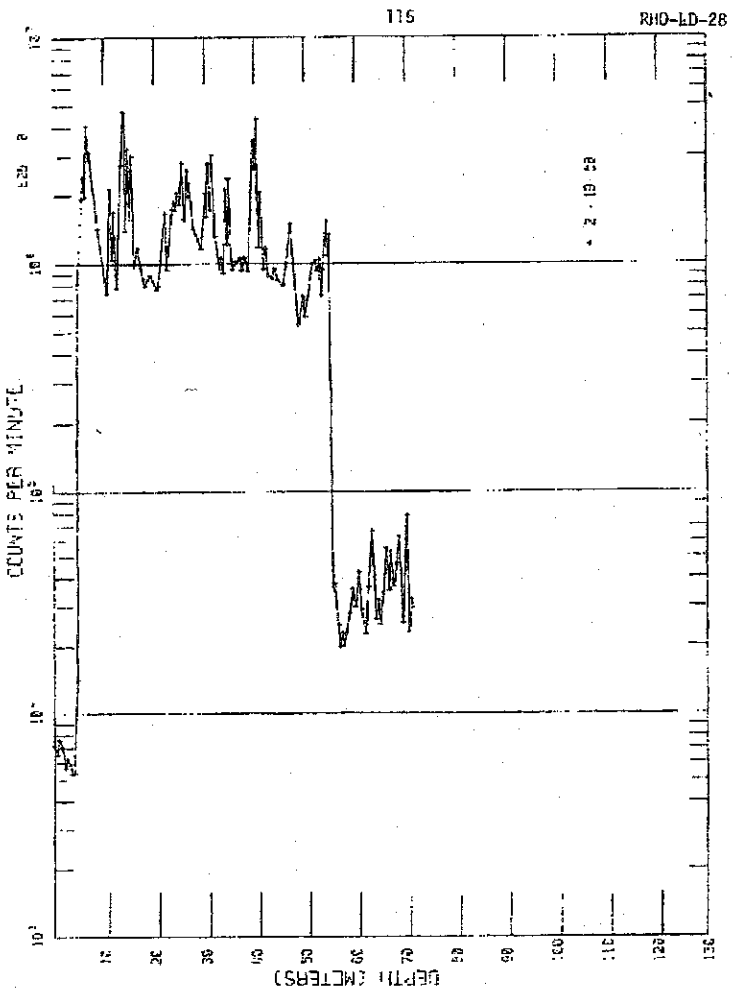
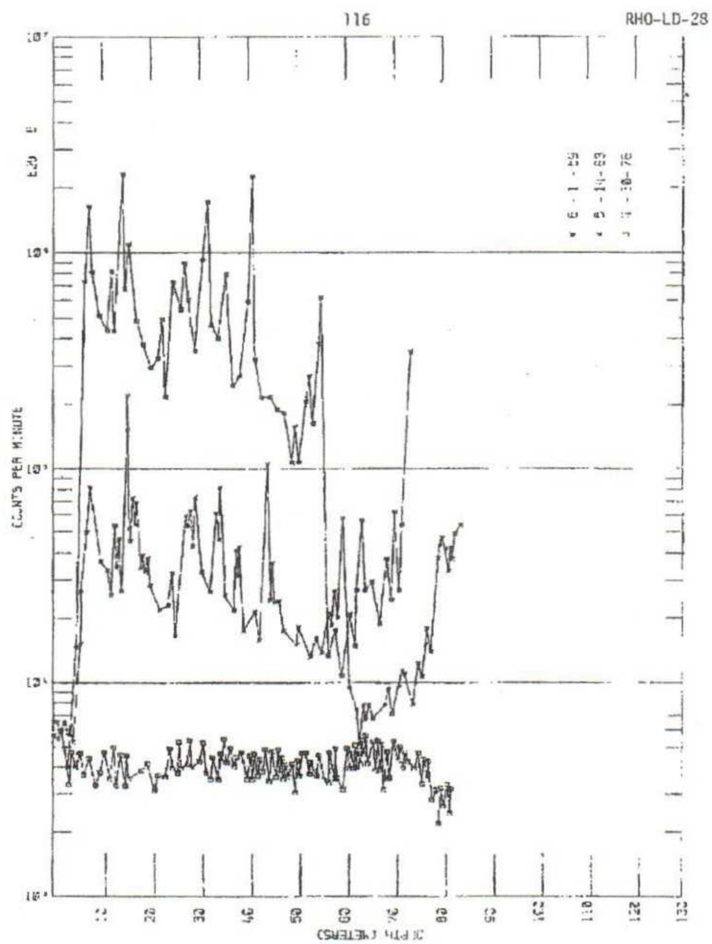
[1] GWL – groundwater level
[2] TOC – top of casing
[3] HWIS – Hanford Well Information System
[4] N/A – not applicable



from Additon et al. (1978)

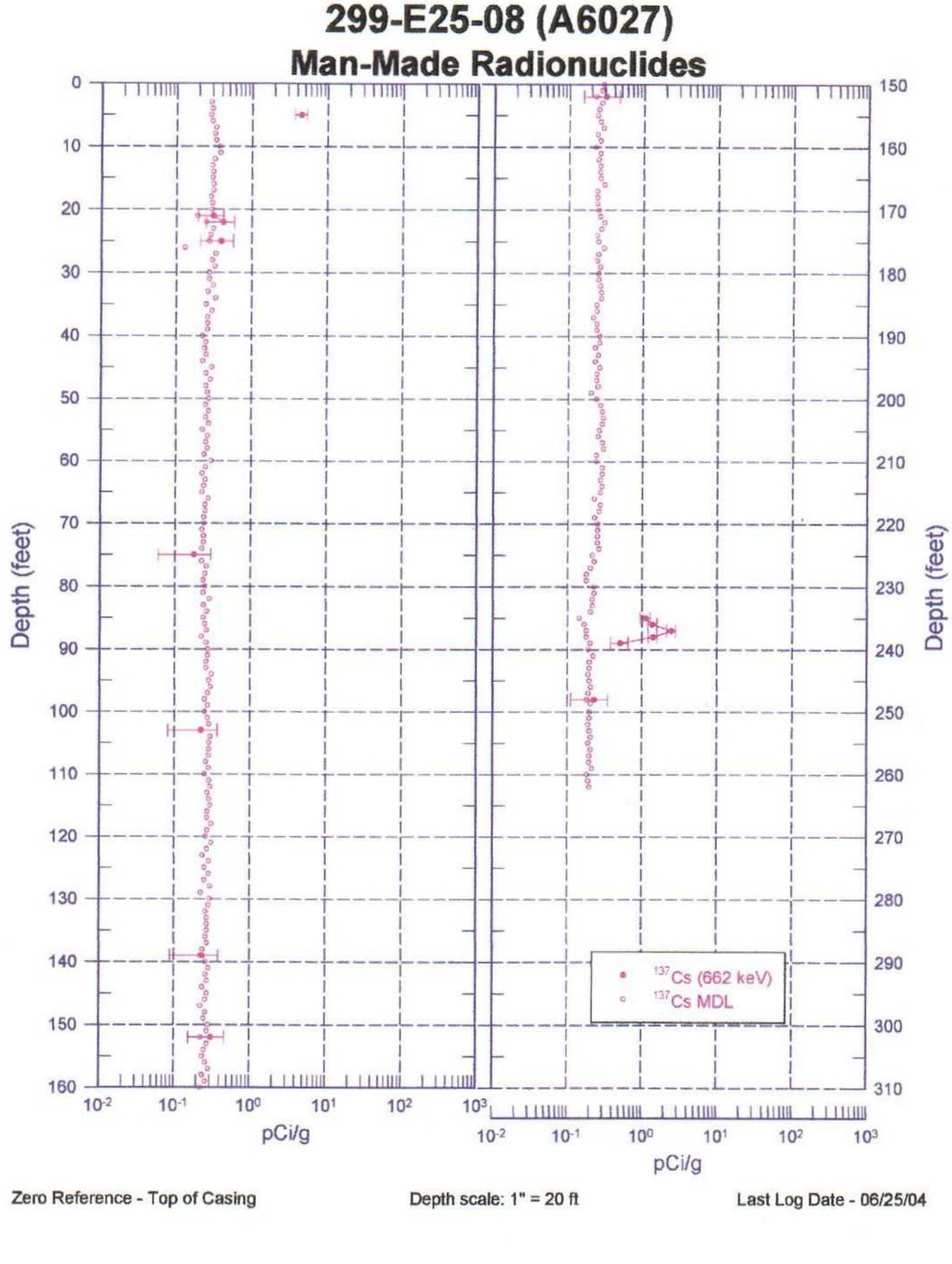
Scintillation Probe Profiles for Borehole 299-E25-8, Logged on 2/19/58

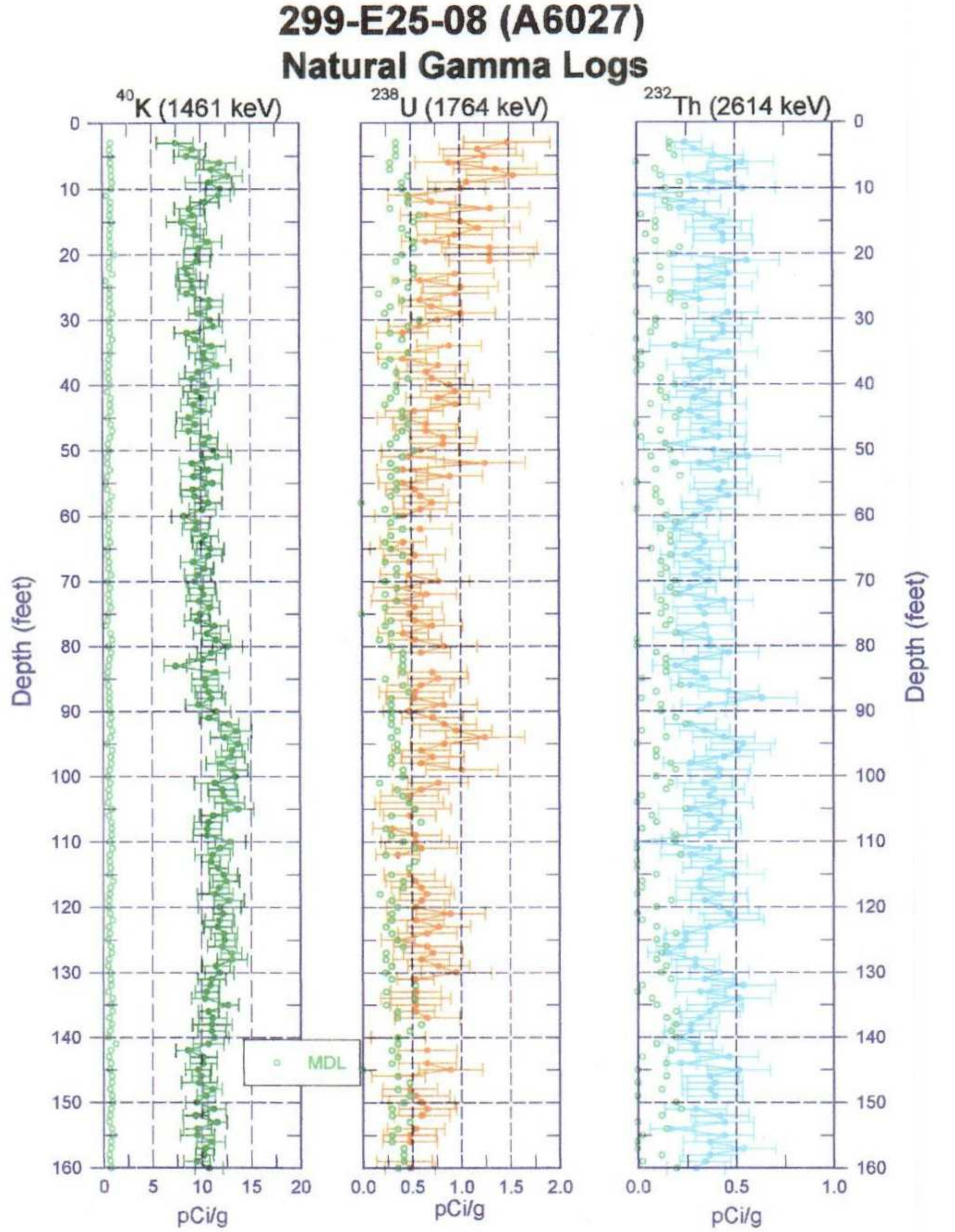
Page 4



from Additon et al. (1978)

Scintillation Probe Profile for Borehole 299-E25-8, Logged on 6/1/59, 5/14/63, and 4/30/76


299-E25-08 (A6027)
Man-Made Radionuclides
Depth (feet)
pCi/g
137Cs (662 keV)
137Cs MDL
Zero Reference - Top of Casing
Depth scale: 1" = 20 ft
Last Log Date - 06/25/04

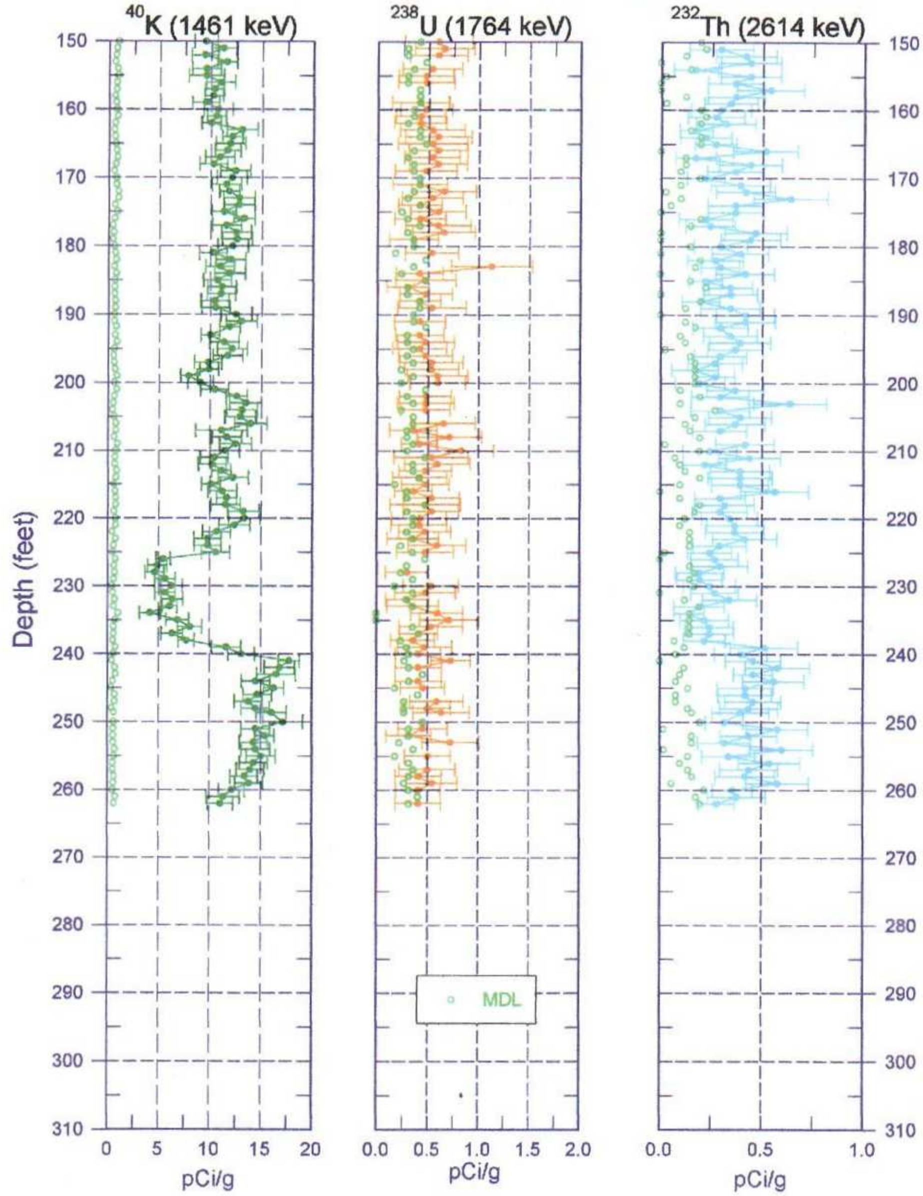


Zero Reference - Top of Casing

Depth scale: 1" = 20 ft

Last Log Date - 06/25/04

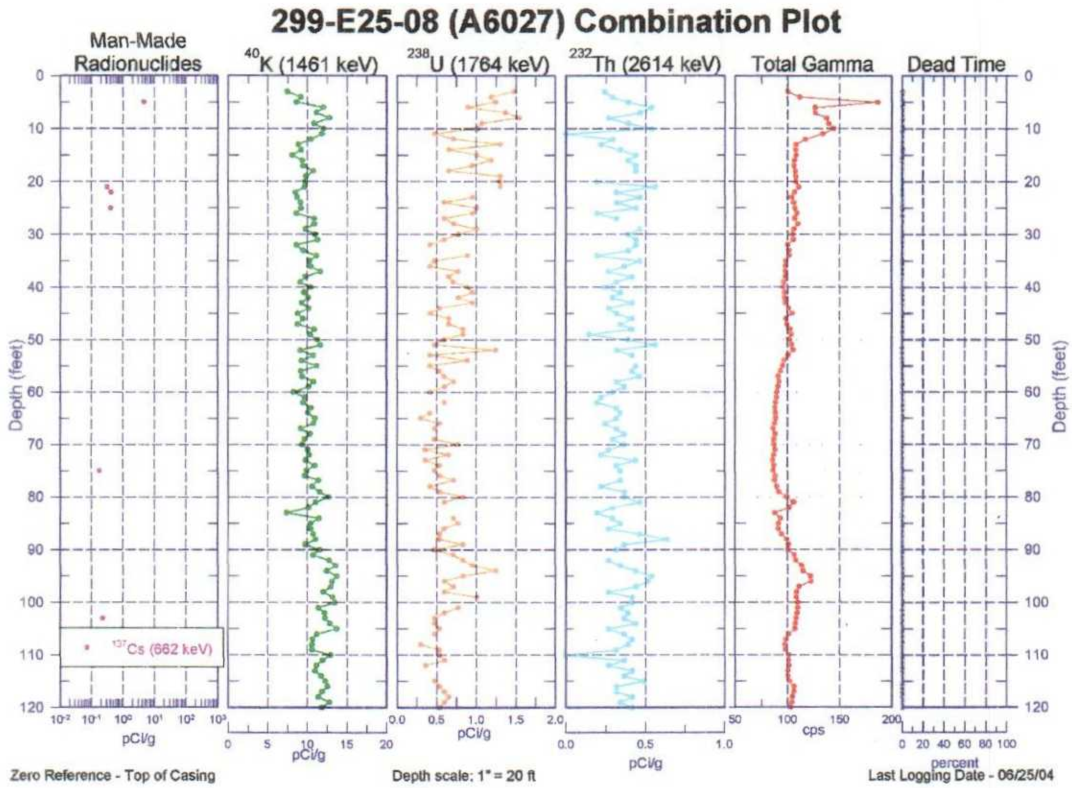
299-E25-08 (A6027)
Natural Gamma Logs

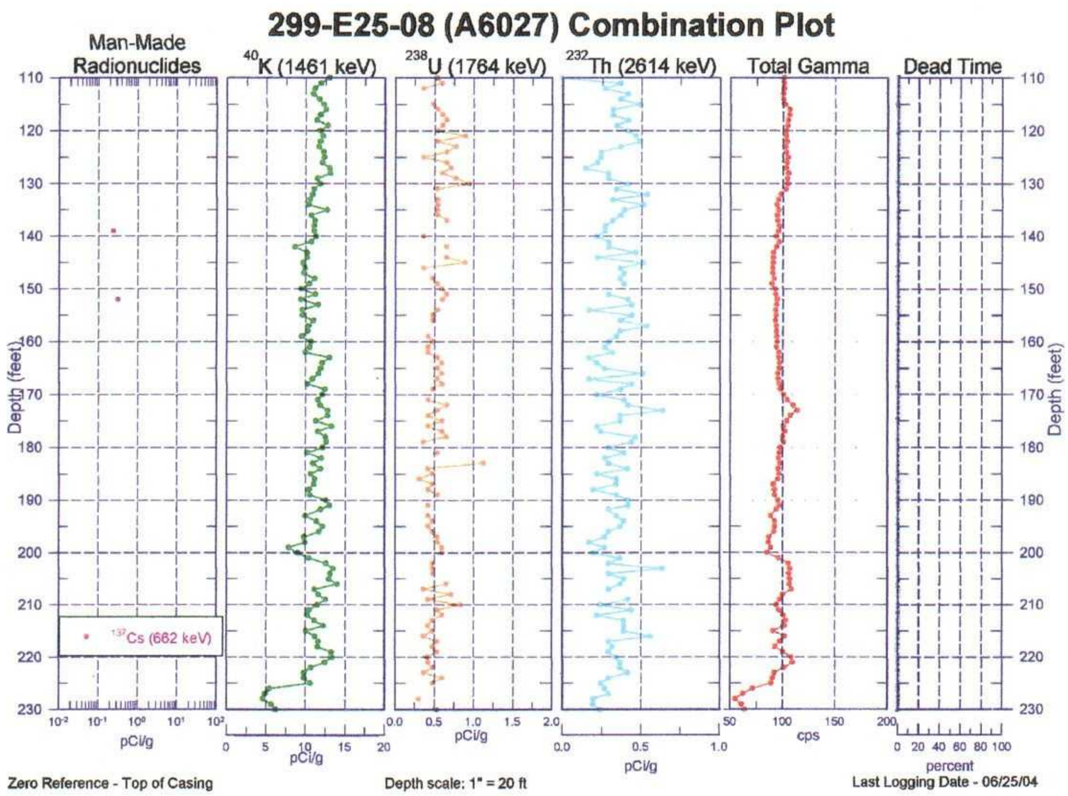


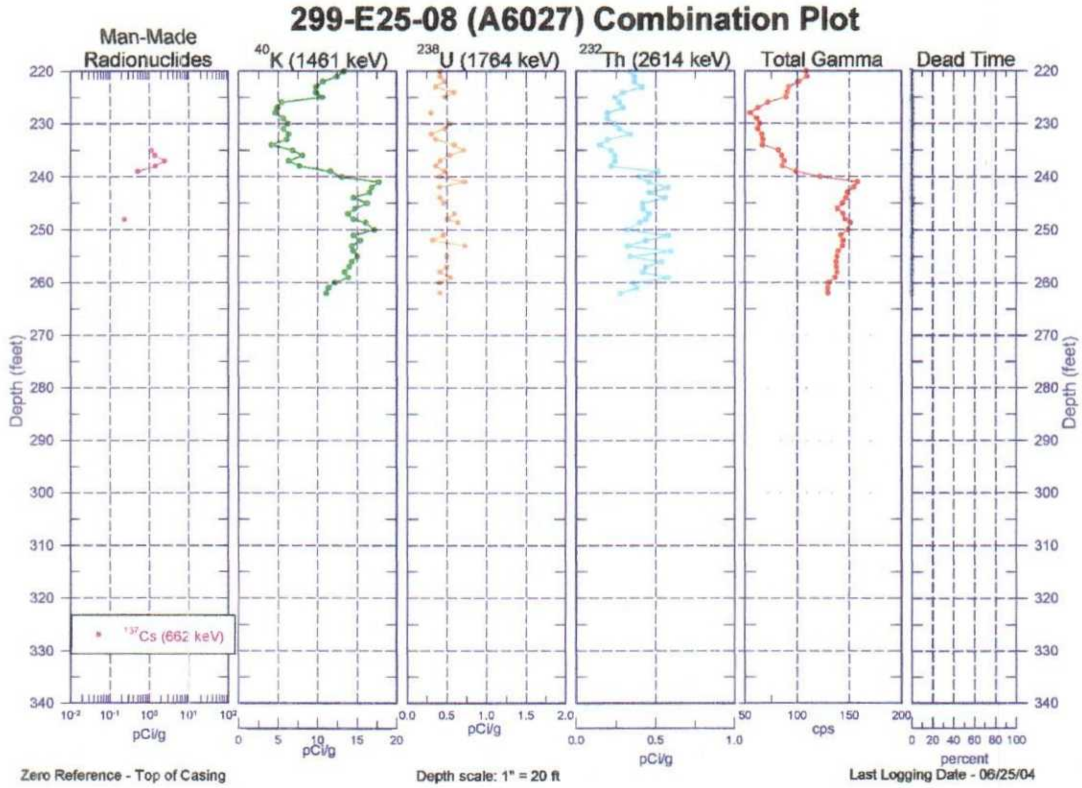
Zero Reference - Top of Casing

Depth scale: 1" = 20 ft

Last Log Date - 06/25/04

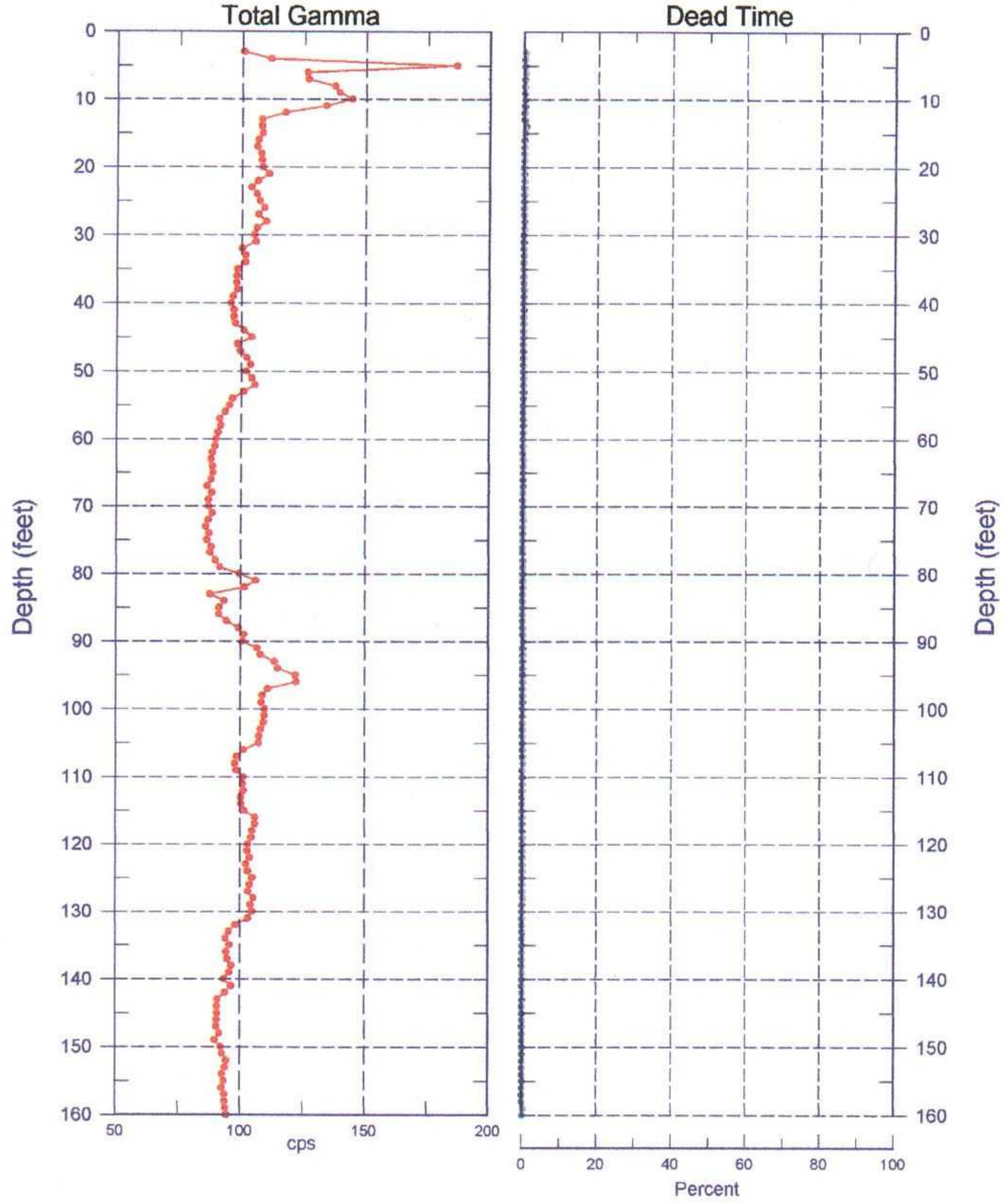

299-E25-08 (A6027) Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
137Cs (662 keV)
pCi/g
cps
percent
Zero Reference - Top of Casing
Depth scale: 1" = 20 ft
Last Logging Date - 06/25/04


299-E25-08 (A6027) Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
137Cs (662 keV)
pCi/g
cps
percent
Zero Reference - Top of Casing
Depth scale: 1" = 20 ft
Last Logging Date - 06/25/04



299-E25-08 (A6027) Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
137Cs (662 keV)
pCi/g
cps
percent
Zero Reference - Top of Casing
Depth scale: 1" = 20 ft
Last Logging Date - 06/25/04

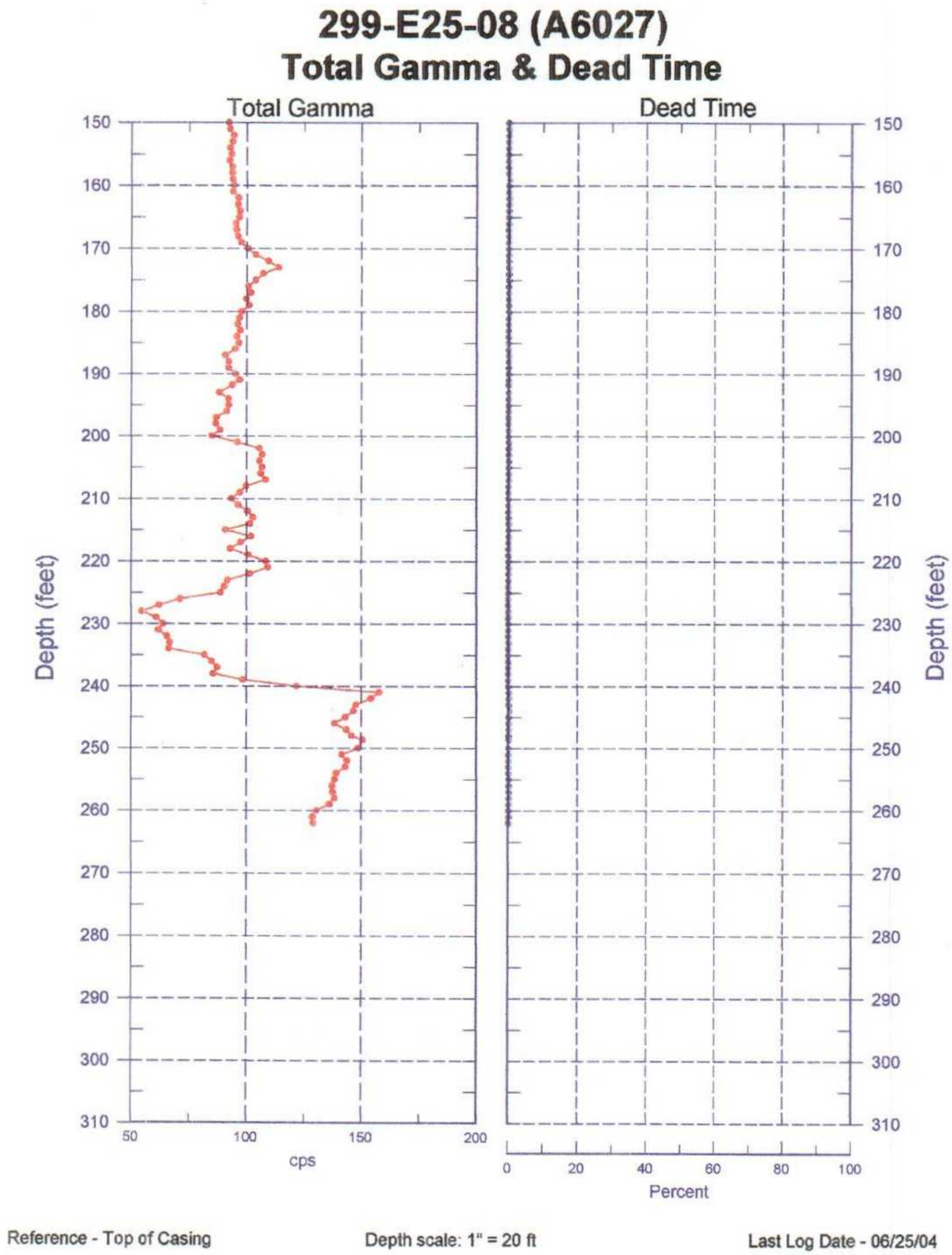
299-E25-08 (A6027)
Total Gamma & Dead Time

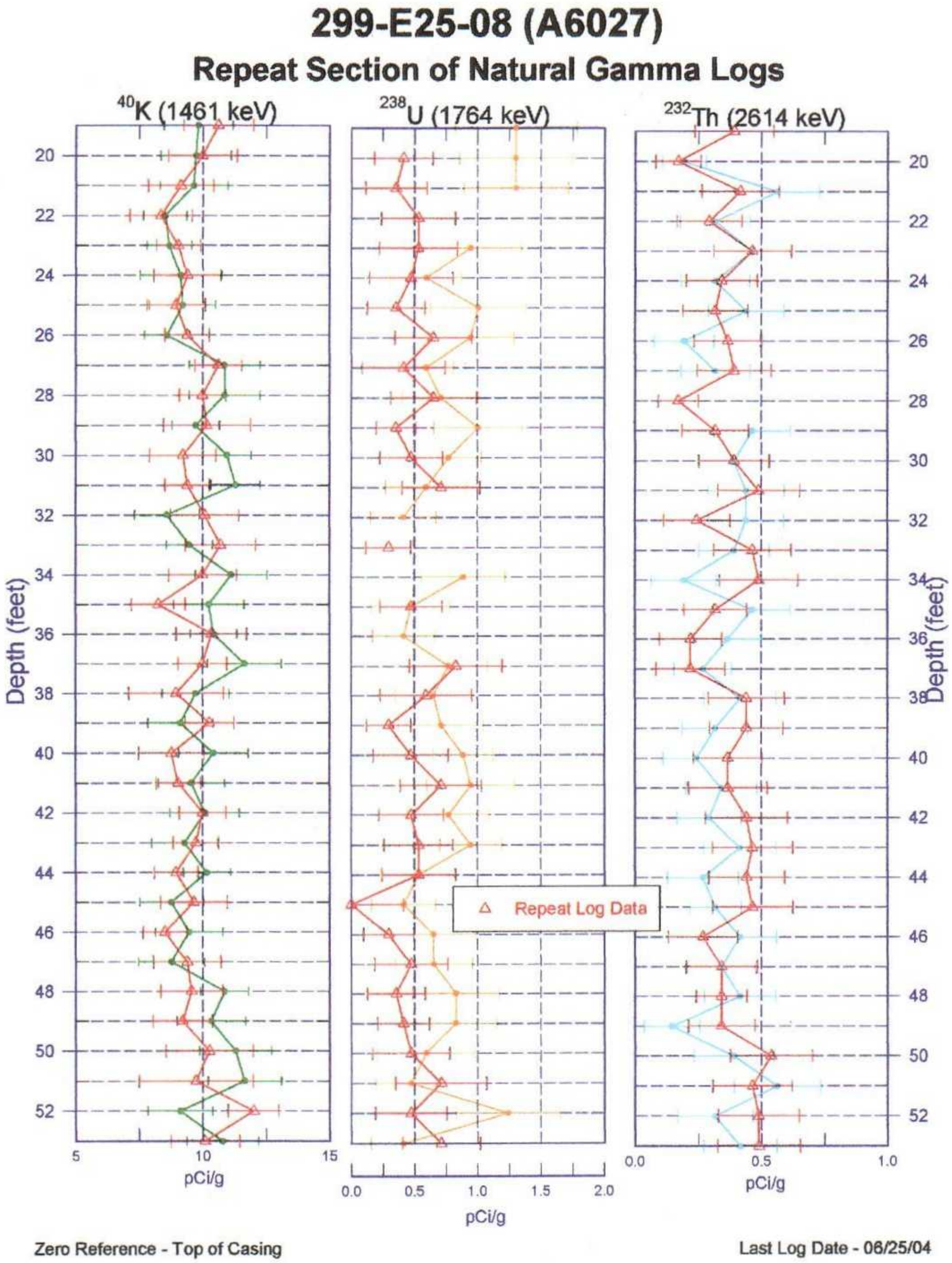


Reference - Top of Casing

Depth scale: 1" = 20 ft

Last Log Date - 06/25/04


299-E25-08 (A6027)
Total Gamma & Dead Time
Total Gamma
Dead Time
Depth (feet)
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
50
100
150
200
cps
0
20
40
60
80
100
Percent
Reference - Top of Casing
Depth scale: 1" = 20 ft
Last Log Date - 06/25/04


299-E25-08 (A6027)
Repeat Section of Natural Gamma Logs
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Depth (feet)
pCi/g
Repeat Log Data
Zero Reference - Top of Casing
Last Log Date - 08/25/04

299-E25-09 (A4797)
Log Data Report

Borehole Information:

Borehole:	299-E25-09 (A4797)		Site:	216-A-8 Crib	
Coordinates (WA State Plane)		GWL (ft)[1]:	259.8	GWL Date:	06/28/04
North	East	Drill Date	TOC[2] Elevation	Total Depth (ft)	Type
136,219.638 m	575,914.147 m	May 1956	201.448 m	288	Cable Tool

Casing Information:

Casing Type	Stickup (ft)	Outer Diameter (in.)	Inside Diameter (in.)	Thickness (in.)	Top (ft)	Bottom (ft)
Welded steel	+1.8	6 5/8	6 1/8	1/4	+1.8	228
Welded steel	0	unknown	unknown	unknown	0	288

The logging engineer measured the casing stickup using a steel tape. A caliper was used to determine the outside casing diameter. The caliper and inside casing diameter were measured using a steel tape. Measurements were rounded to the nearest 1/16 in. Casing thickness was calculated. The 8-in. casing is not visible at the ground surface. Surrounding the casing on top of the ground surface is a 2-ft by 6-in. round concrete pad.

Borehole Notes:

Borehole coordinates, elevation, and well construction information are from measurements by Stoller field personnel, HWIS[3], and Ledgerwood (1993). Zero reference is the top of the 6-in. casing. Before logging began the borehole was swabbed. No radioactivity was detected on the swab sample.

Logging Equipment Information:

Logging System:	Gamma 2A		Type: 35% HPGe (34TP20893A)
Calibration Date:	03/04	Calibration Reference:	DOE-EM/GJ642-2004
		Logging Procedure:	MAC-HGLP 1.6.5, Rev. 0

Spectral Gamma Logging System (SGLS) Log Run Information:

Log Run	1	2	3	4	5 / Repeat
Date	06/25/04	06/28/04	06/29/04	06/30/04	07/01/04
Logging Engineer	Spatz	Spatz	Spatz	Spatz	Spatz
Start Depth (ft)	16.0	120.0	160.0	259.0	28.0
Finish Depth (ft)	3.0	15.0	119.0	159.0	3.0
Count Time (sec)	200	200	200	200	200
Live/Real	R	R	R	R	R
Shield (Y/N)	N	N	N	N	N
MSA Interval (ft)	1.0	1.0	1.0	1.0	1.0
ft/min	N/A[4]	N/A	N/A	N/A	N/A

Log Run	1	2	3	4	5 / Repeat
Pre-Verification	BA353CAB	BA355CAB	BA356CAB	BA357CAB	BA358CAB
Start File	BA354000	BA355000	BA356000	BA357000	BA358000
Finish File	BA354013	BA355105	BA356042	BA357100	BA358025
Post-Verification	BA354CAA	BA355CAA	BA356CAA	BA357CAA	BA358CAA
Depth Return Error (in.)	0	0	0	-1	0
Comments	No fine gain adjustment.	Fine gain adjustment after files: -016, -047, -062, -079, and -095.	No fine gain adjustment.	Fine gain adjustment after files: -068 and -087.	No fine gain adjustment.

Logging Operation Notes:

Zero reference was top of the 6-in. casing. Logging was performed without the centralizer on the sonde for spectral data collected on 06/30/04 (log run 4). Pre- and post-survey verification measurements for the SGLS employed the Amersham KUT (^{40}K, ^{238}U, and ^{232}Th) verifier with serial number 082. Maximum logging depth achieved was 259.0 ft, approximately 1 ft above groundwater.

Analysis Notes:

Analyst:	Henwood	Date:	07/07/04	Reference:	GJO-HGLP 1.6.3, Rev. 0

SGLS pre-run and post-run verification spectra were collected at the beginning and end of each day. All of the verification spectra were within the acceptance criteria.

Log spectra for the SGLS were processed in batch mode using APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Verification spectra were used to determine the energy and resolution calibration for processing the data using APTEC SUPERVISOR. Concentrations were calculated in EXCEL (source file: G2AMAR04.xls), using parameters determined from analysis of recent calibration data. Zero reference was the top of the 6-in. casing. Based on Ledgerwood (1993), the casing configuration was assumed to be a string of 6-in. casing with a thickness of 1/4 in. to a log depth of 228 ft and a string of 8-in. casing with a thickness of 0.322 in. to the depth of 288 ft. The 6-in. casing thickness was measured by the logging engineer. A casing thickness of 0.322 in. was assumed for the 8-in. casing. This thickness is the published value for ASTM schedule-40 steel pipe, a commonly used casing material at Hanford. Where more than one casing exists at a depth, the casing correction is additive (e.g., the correction for both 6-in. and 8-in. casing would be 0.25 + 0.322 = 0.572). Water and dead time corrections were not required.

Log Plot Notes:

Separate log plots are provided for gross gamma and dead time, naturally occurring radionuclides (^{40}K, ^{238}U, and ^{232}Th), and man-made radionuclides. Plots of the repeat logs versus the original logs are included. For each radionuclide, the energy value of the spectral peak used for quantification is indicated. Unless otherwise noted, all radionuclides are plotted in picocuries per gram (pCi/g). The open circles indicate the minimum detectable level (MDL) for each radionuclide. Error bars on each plot represent error associated with counting statistics only and do not include errors associated with the inverse efficiency function, dead time correction, or casing correction. These errors are discussed in the calibration report. A combination plot is also included to facilitate correlation. The ^{214}Bi peak at 1764 keV was used to determine the naturally occurring ^{238}U concentrations on the combination plot.

Results and Interpretations:

^{137}Cs was the only man-made radionuclide detected in this borehole. ^{137}Cs was detected near the ground surface, at a few sporadic locations throughout the borehole, between 226 and 239 ft, and between 246 and 250 ft. The range of concentrations was from the MDL (0.2 pCi/g) to 13 pCi/g, which was measured at 5 ft. The ^{137}Cs detected at log depths between 226 and 232 ft is located at a depth interval consistent with the depth of a packer set at 228 ft. ^{137}Cs detected at 239 ft is approximately 20 ft above the current groundwater level. It is possible that a groundwater mound existed in the area in the past and the ^{137}Cs below 239 ft is a remnant of contaminated groundwater.

The KUT concentrations above 228 ft appear to be underestimated due to the effects of double casing and grout.

The behavior of the ^{238}U log suggests that radon may be present inside the borehole casing. Determination of ^{238}U is based on measurement of gamma activity at 609 and/or 1764 keV associated with ^{214}Bi, under the assumption of secular equilibrium in the decay chain. However, ^{214}Bi is also a short-term daughter of ^{222}Rn. When radon is present, ^{214}Bi will tend to "plate" onto the casing wall and will quickly reach equilibrium with ^{222}Rn. Because the additional ^{214}Bi resulting from radon is on the inside of the casing, the effect of the casing correction is to amplify the 609 photopeak relative to the 1764 photopeak. (The magnitude of the casing correction factor decreases with increasing energy, but gamma rays originating inside the casing are not attenuated.) This effect is observed in the log data acquired for log run 2 between 15 and approximately 70 ft. The effects of radon appear to be minimal in the other log runs. The reason for variations in radon content between log runs on successive days is not known. Variations in radon content in boreholes are probably related to variations in surface weather conditions. Radon daughters such as ^{214}Bi may also "plate" onto the sonde itself. When this occurs, there is a gradual increase in total counts as well as photopeak counts associated with ^{214}Bi and ^{214}Pb.

The presence of radon is not an indication of man-made contamination; it is derived from decay of naturally occurring uranium. As a gas, radon moves easily in the subsurface, and concentrations of radon and its associated progeny can change quickly.

The plots of the repeat logs demonstrate reasonable repeatability of the SGLS data for the natural radionuclides (1461- and 2614-keV energy levels). The data for the 1764-keV energy peak indicate the effect of the radon between 15 and 28 ft where the original log run shows higher concentrations than the repeat data.

Gross gamma logs from Additon et al. (1977) (attached) indicate that the sediments surrounding this borehole contained significant amounts of man-made gamma radiation extending to groundwater from 1958 through at least 1963. By 1968 most of the gamma activity in the vadose zone had decayed away.

References:

Additon, M.K., K.R. Fecht, T.L. Jones, and G.V. Last, 1978. *Scintillation Probe Profiles From 200 East Area Crib Monitoring Wells*, RHO-LD-28, Rockwell Hanford Operations, Richland, Washington.

Ledgerwood, R.K., 1993. *Summaries of Well Construction Data and Field Observations for Existing 200-East Resource Protection Wells*, WHC-SD-ER-TI-007, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

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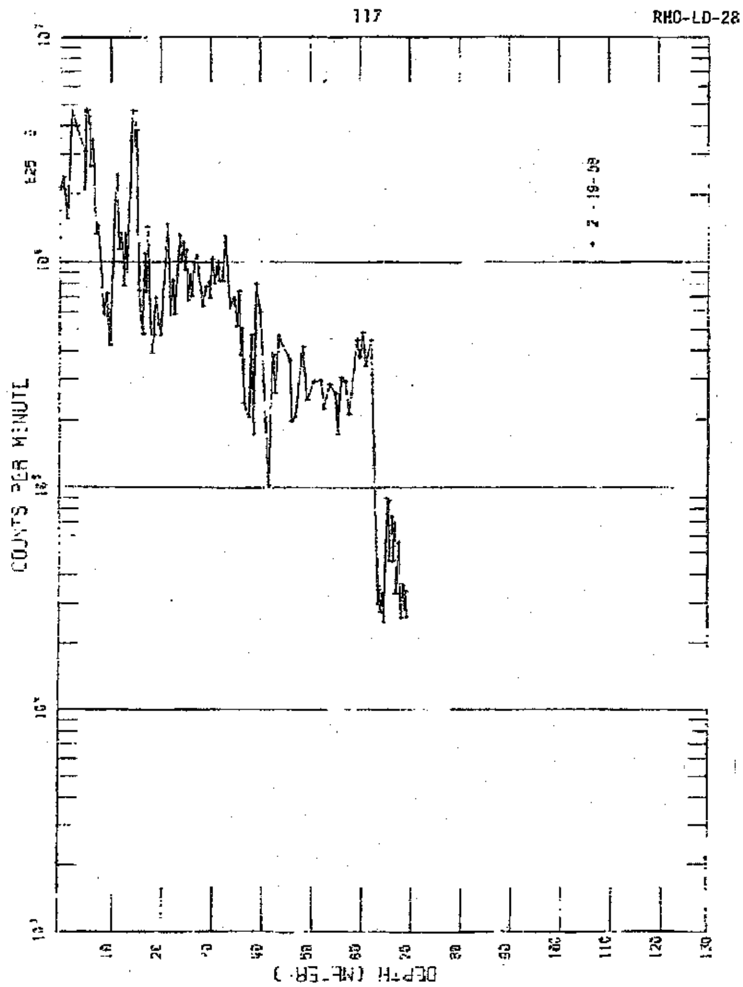
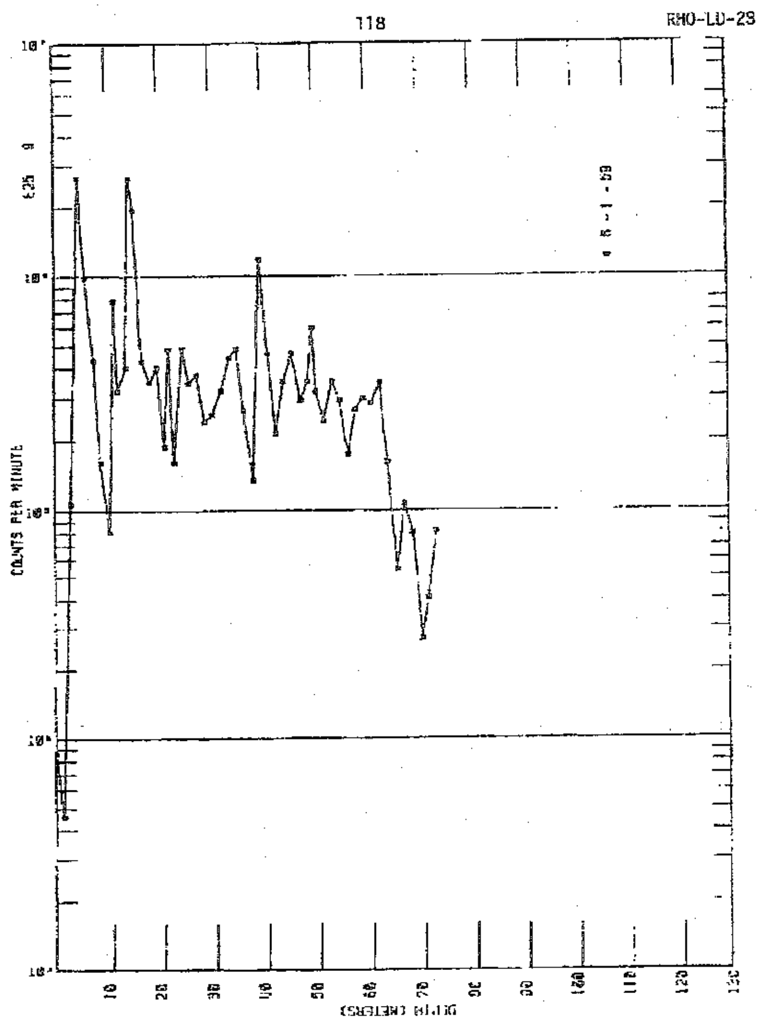
[1] GWL – groundwater level
[2] TOC – top of casing
[3] HWIS – Hanford Well Information System
[4] N/A – not applicable



from Additon et al. (1978)

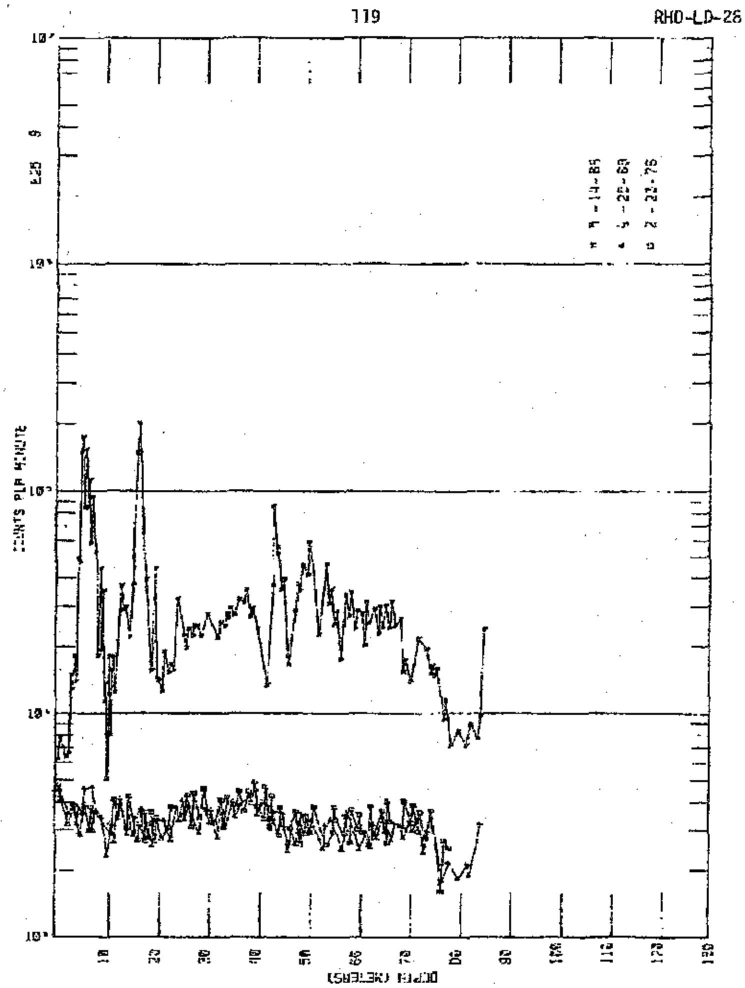
Scintillation Probe Profiles for Borehole 299-E25-9, Logged on 2/19/58



from Additon et al. (1978)

Scintillation Probe Profile for Borehole 299-E25-9, Logged on 6/1/59

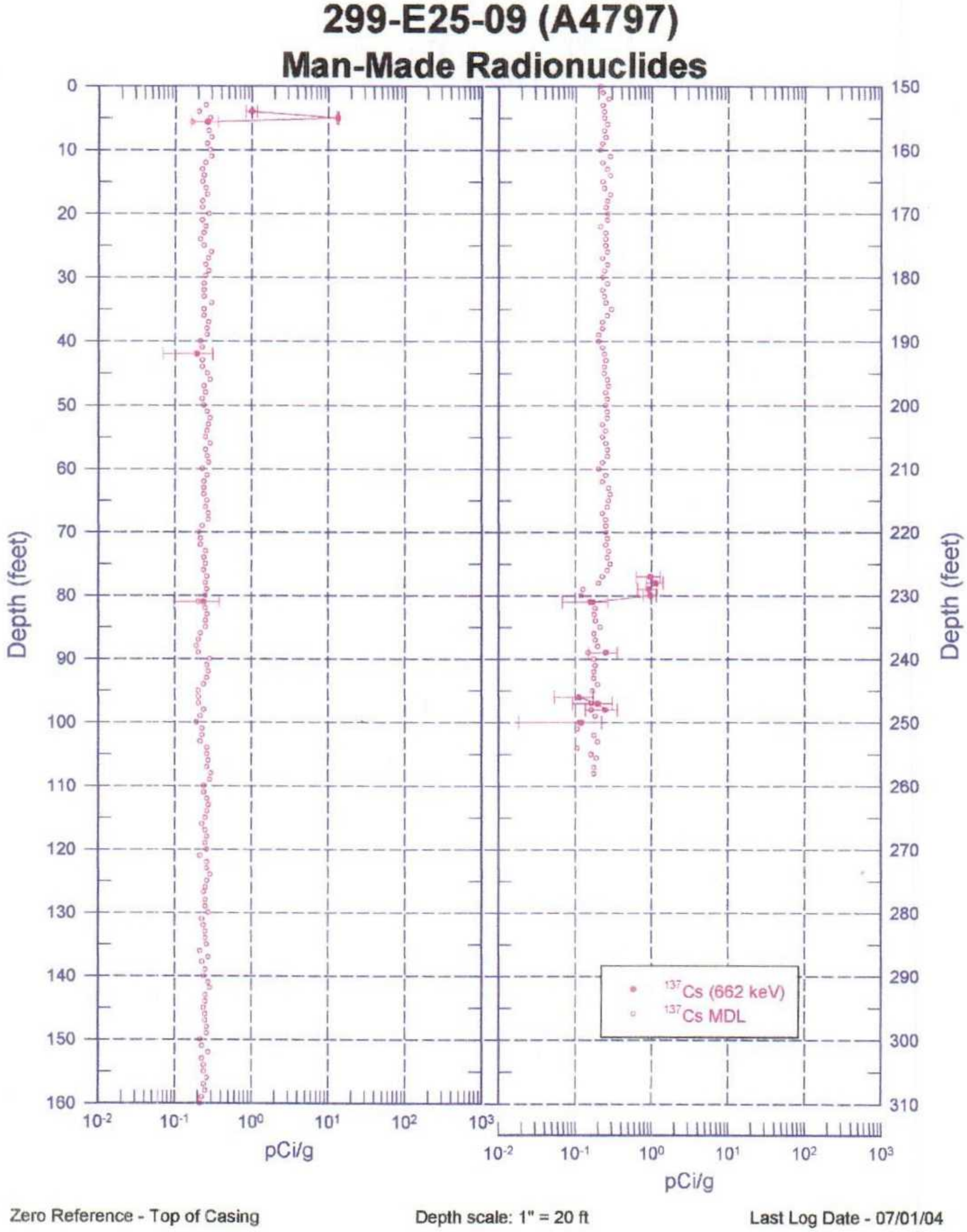
Page 5



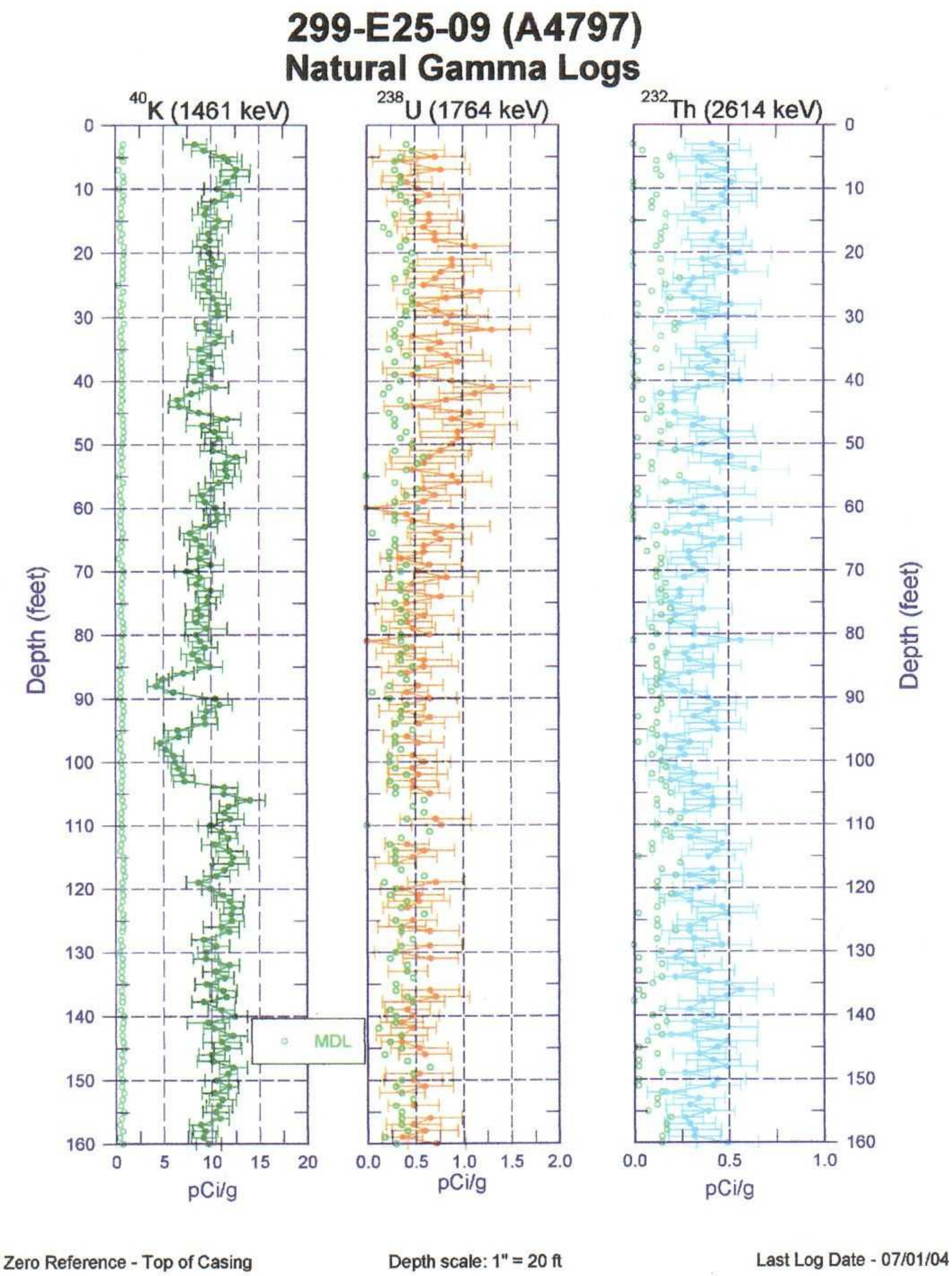
from Additon et al. (1978)

Scintillation Probe Profile for Borehole 299-E25-9, Logged on 5/14/63, 4/25/68, and 2/20/76

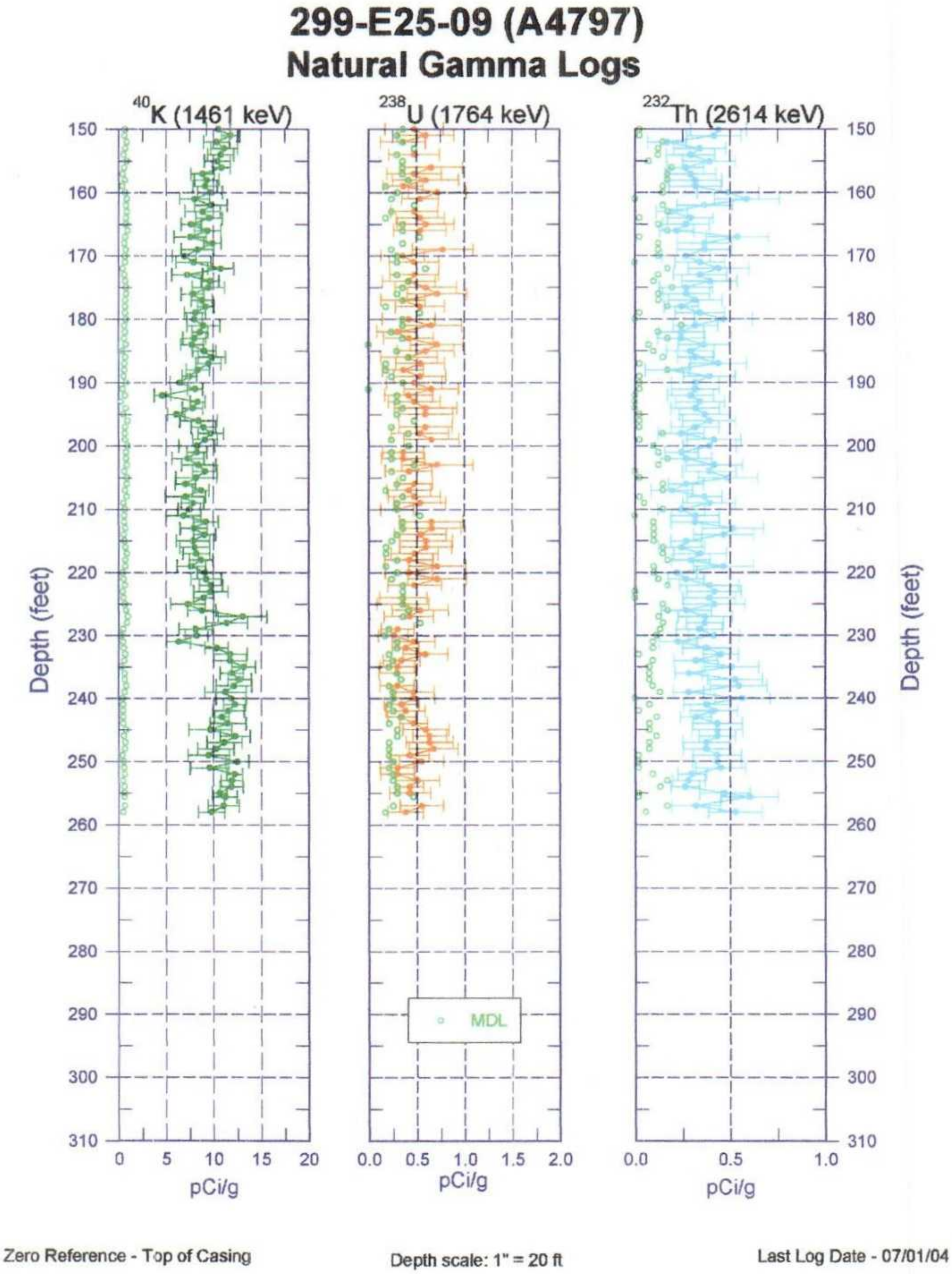
Page 6

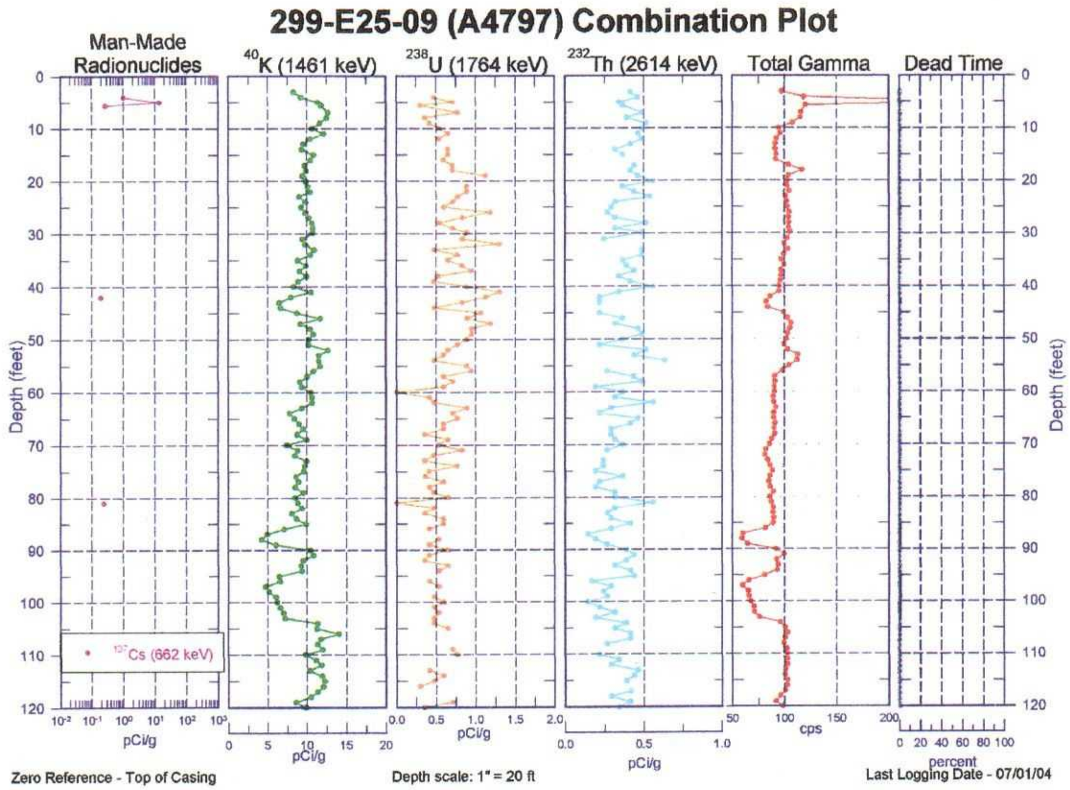


299-E25-09 (A4797)
Man-Made Radionuclides
Depth (feet)
pCi/g
^{137}Cs (662 keV)
^{137}Cs MDL
Zero Reference - Top of Casing
Depth scale: 1" = 20 ft
Last Log Date - 07/01/04

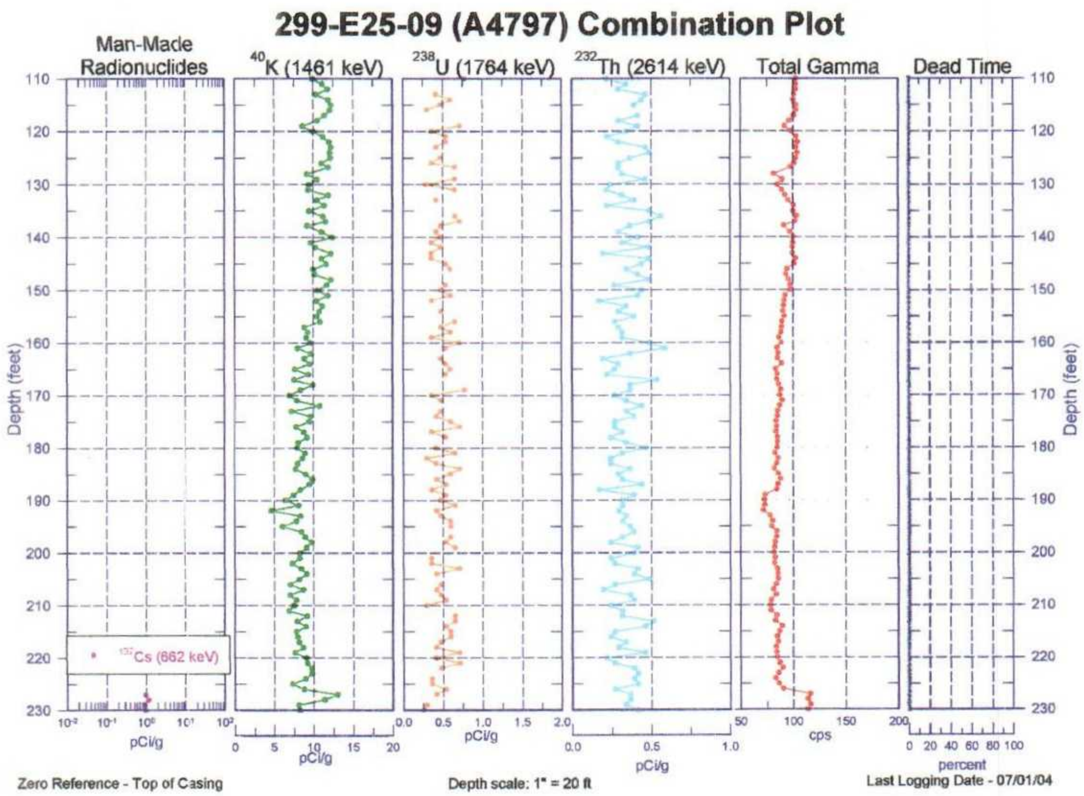


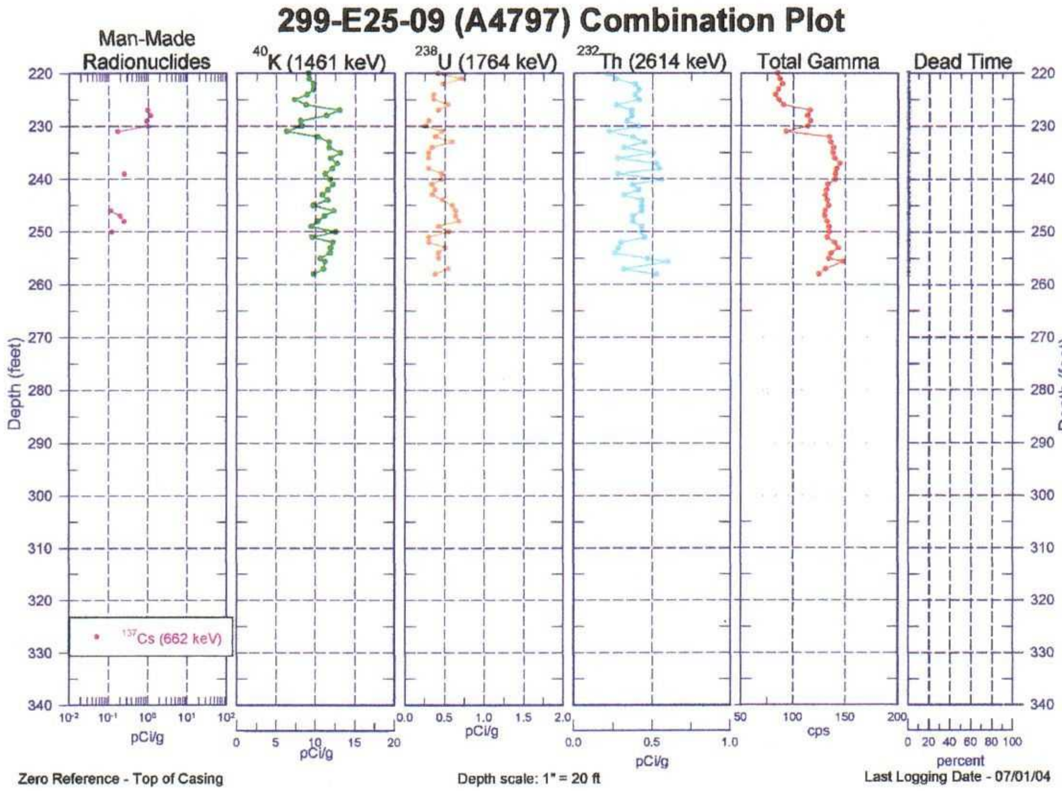
299-E25-09 (A4797)
Natural Gamma Logs
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
0 5 10 15 20
0.0 0.5 1.0 1.5 2.0
0.0 0.5 1.0
pCi/g
MDL
Zero Reference - Top of Casing
Depth scale: 1" = 20 ft
Last Log Date - 07/01/04


299-E25-09 (A4797)
Natural Gamma Logs
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Depth (feet)
pCi/g
MDL
Zero Reference - Top of Casing
Depth scale: 1" = 20 ft
Last Log Date - 07/01/04

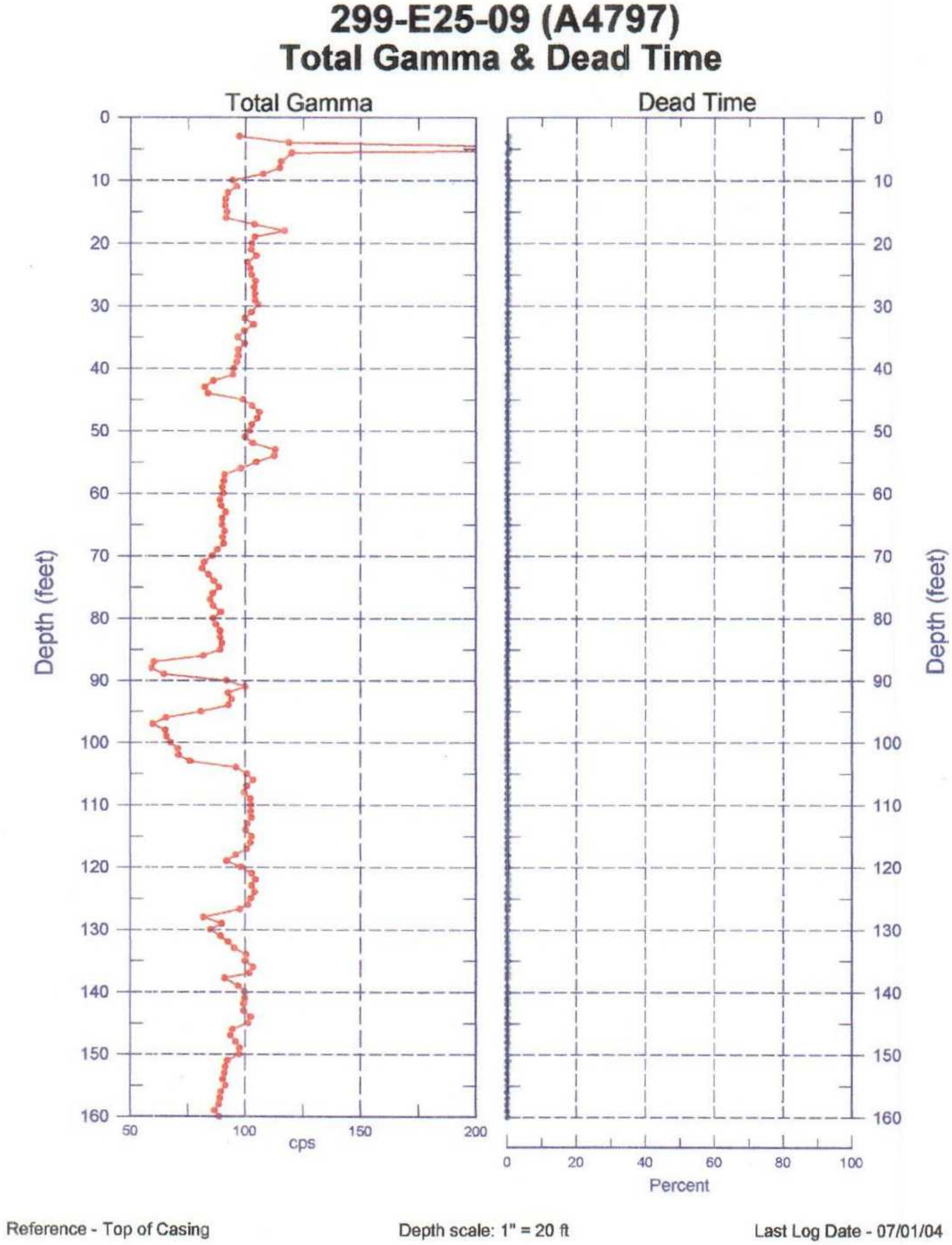


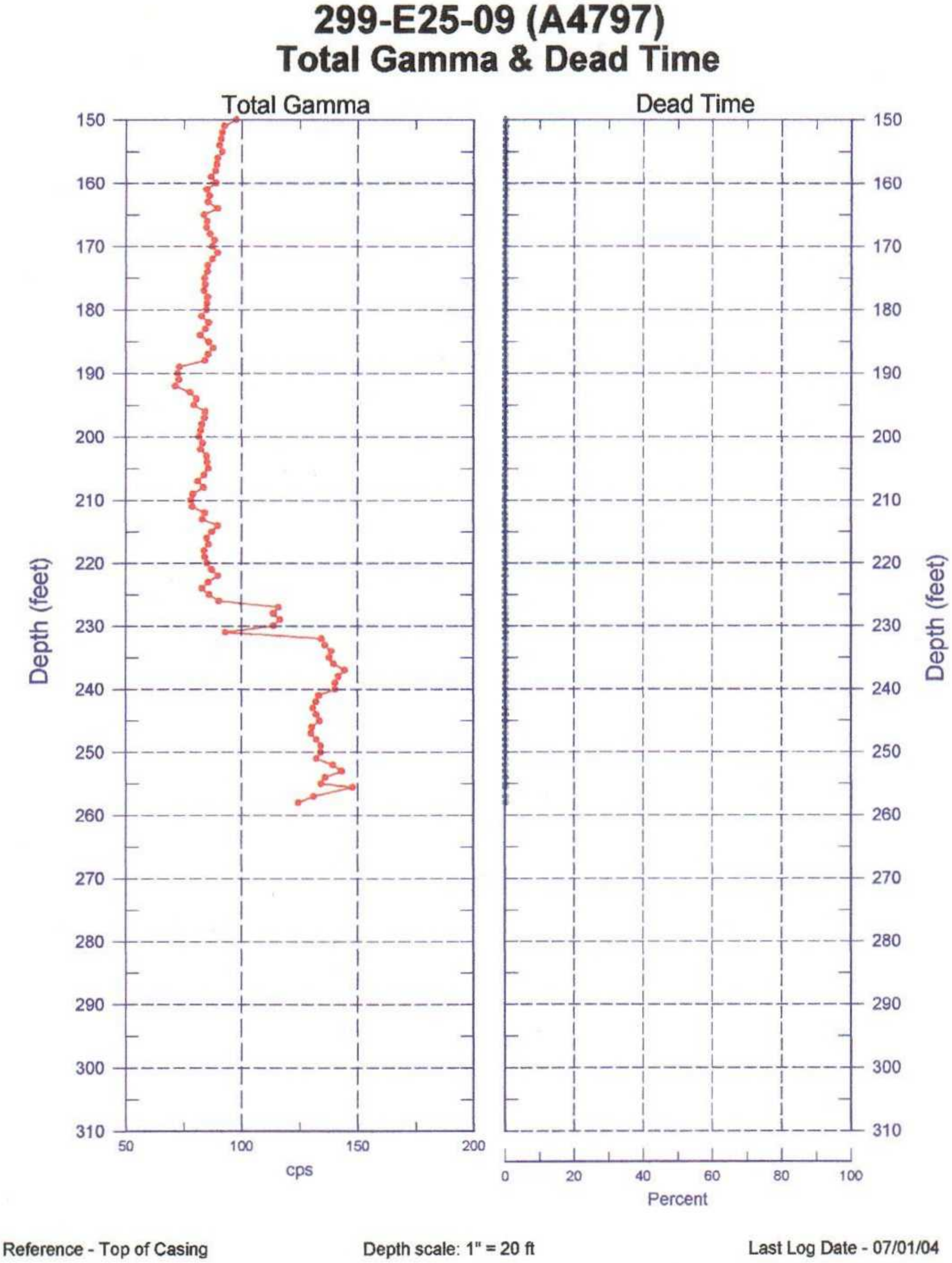
299-E25-09 (A4797) Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
137Cs (662 keV)
pCi/g
cps
percent
Zero Reference - Top of Casing
Depth scale: 1" = 20 ft
Last Logging Date - 07/01/04

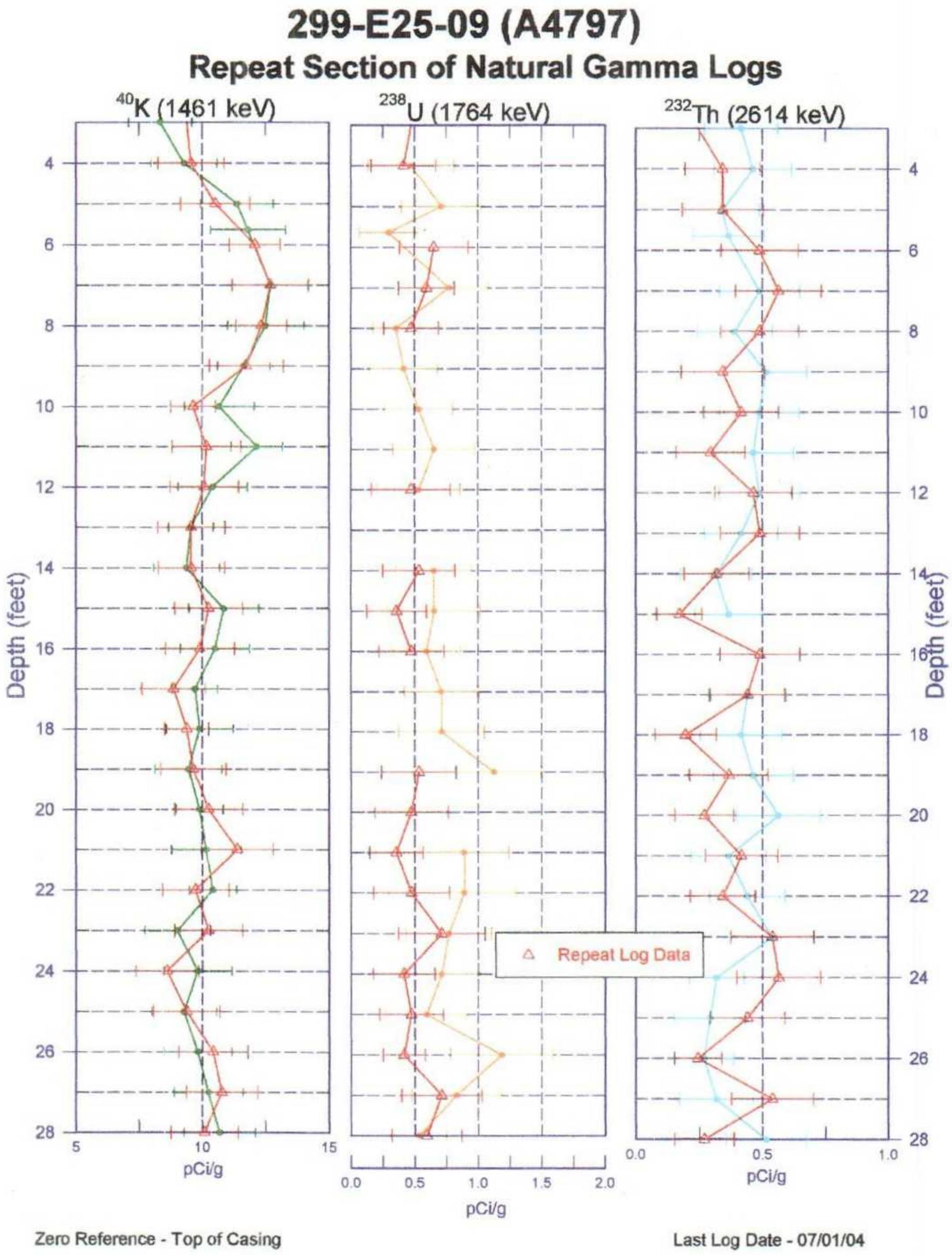

299-E25-09 (A4797) Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
137Cs (662 keV)
pCi/g
cps
percent
Zero Reference - Top of Casing
Depth scale: 1" = 20 ft
Last Logging Date - 07/01/04



299-E25-09 (A4797) Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
137Cs (662 keV)
pCi/g
cps
percent
Zero Reference - Top of Casing
Depth scale: 1" = 20 ft
Last Logging Date - 07/01/04


299-E25-09 (A4797)
Total Gamma & Dead Time
Total Gamma
Dead Time
Depth (feet)
cps
Percent
Reference - Top of Casing
Depth scale: 1" = 20 ft
Last Log Date - 07/01/04


299-E25-09 (A4797)
Total Gamma & Dead Time
Total Gamma
Dead Time
Depth (feet)
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
50
100
150
200
cps
0
20
40
60
80
100
Percent
Reference - Top of Casing
Depth scale: 1" = 20 ft
Last Log Date - 07/01/04


299-E25-09 (A4797)
Repeat Section of Natural Gamma Logs
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Depth (feet)
pCi/g
Repeat Log Data
Zero Reference - Top of Casing
Last Log Date - 07/01/04

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APPENDIX D

WELL SUMMARY SHEET FOR BOREHOLE C4545

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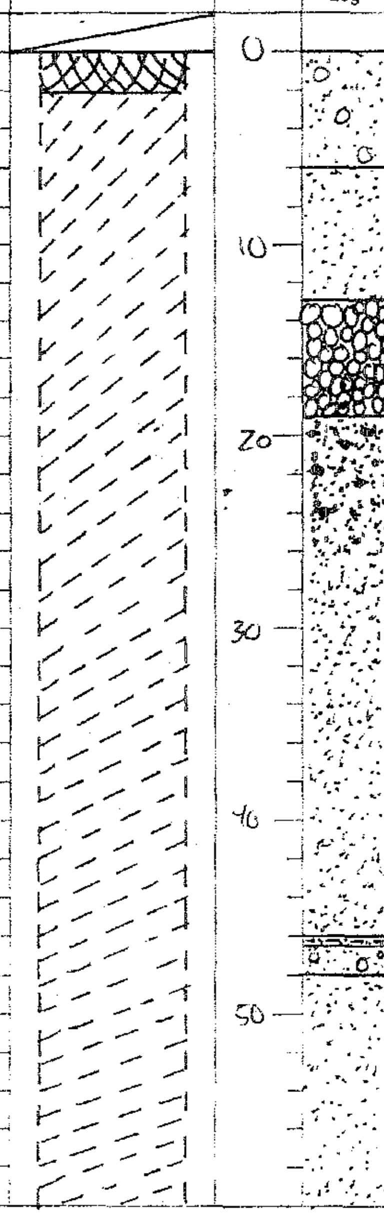
APPENDIX D

WELL SUMMARY SHEET FOR BOREHOLE C4545

WELL SUMMARY SHEET

Start Date: 6-6-05	Page 1 of 5
Finish Date: 7-21-05	
Well ID: C4545	Well Name: ~~A-8 Borehole~~ C4545
Location: 216-A-8 Crib	Project: A-8 Characterization
Prepared By: Robin Henderson Date: 8-1-05	Reviewed By: L.D. Walker Date: 8/9/05
Signature: Robin Henderson	Signature: [signature]

CONSTRUCTION DATA – Description	Depth in Feet	GEOLOGIC/HYDROLOGIC DATA – Lithologic Description
Portland Cement Grout: 0' → 1'	0	0' → 6' gravelly Sand
		6' → 13' Sand
Granular Bentonite Annual Seal: 1' → 256.9'	10	13' → 19' Gravel
	20	19' → 46' Sand
		46' → 46.5' Silty Sand
	30	
	40	46.5' → 48' Sand
		48' → 55' Gravelly Sand
	50	55' → 97.5' Sand



A-6003-643 (03/0…)

WELL SUMMARY SHEET	Start Date: 6-6-05 Finish Date: 7-21-05	Page 2 of 5

Well ID: C4545	Well Name: ~~2 A-8 Borehole~~ C4545
Location: 216-A-8 Crib	Project: A-8 Characterization
Prepared By: R. Henderson Date: 7-31-05	Reviewed By: L.D. Walker Date: 8/9/05
Signature: Robin Henderson	Signature:

CONSTRUCTION DATA Description	Diagram	Depth in Feet	GEOLOGIC/HYDROLOGIC DATA Graphic Log	Lithologic Description
		60		55' → 97.5' Sand
		70		
		80		
		90		
				97.5' → 99' Gravelly Silty Sand
				99' → 104' Silty Sand
		100		
				104' → 108' Sand
				108' → 112' Gravelly Silty Sand
		110		112' → 119' Sand
				119' → 123' Silty Sand

A-6003-643 (03/03)

WELL SUMMARY SHEET

Start Date: 6-6-05	Page 3 of 5
Finish Date: 7-21-05	

Well ID: C4545	Well Name: ~~AG Borehole~~ C4545
Location: 216-A-8 Crib	Project: 216-A-8 Characterization
Prepared By: R Henderson Date: 7-21-05	Reviewed By: L.D. Walker Date: 8/9/05
Signature: Robin Henderson	Signature: LD Walker

CONSTRUCTION DATA: Description	Diagram	Depth in Feet	Graphic Log	GEOLOGIC/HYDROLOGIC DATA: Lithologic Description
		120		119' → 123' Silty Sand
				123' → 127' Sand
				127' → 133' Slightly Silty Sand
		130		
				133' → 138' silty sand
				138' → 144' Sand
		140		
				144' → 149' Slightly Silty Gravelly Sand
				149' → 150' Sand
		150		150' → 153' Slightly silty Gravelly Sand
				153' → 158.5' Sand
				158.5' → 162' slightly silty sand
		160		162' → 166' Sand
				166' → 167' slightly silty sand
				167' → 168' silty sand
				168' → 168.5' silt
		170		168.5' → 171' slightly silty sand
				171' → 171.5' silt
				171.5' → 173' slightly silty sand
				173' → 178' gravelly sand
				178' → 194' silty sandy gravel

A-6003-643 (03/03)

WELL SUMMARY SHEET	Start Date: 6-6-05 / Finish Date: 7-21-05	Page 4 of 5

Well ID: C4545		Well Name: ~~A-8 Borehole~~ C4545	
Location: 216-A-8 CRib		Project: A-8 Characterization	
Prepared By: R. Henderson	Date: 7-31-05	Reviewed By: L.D. Walker	Date: 8/9/05
Signature: Robin Henderson		Signature: [signature]	

CONSTRUCTION DATA: Description	CONSTRUCTION DATA: Diagram	Depth in Feet	GEOLOGIC/HYDROLOGIC DATA: Graphic Log	GEOLOGIC/HYDROLOGIC DATA: Lithologic Description
		180		178' → 194' silty sandy gravel
		190		194' → 205' Gravelly Sand
		200		205' → 210' silty sandy gravel
		210		210' → 217.5' Sandy Gravel
				217.5' → 222' Gravelly Sand
		220		222' → 222.5' Silty Sand
				222.5' → 225' Gravelly Sand
				225' → 227' sandy Gravel
				227' → 232' Gravelly Sand
		230		232' → 237.5' Sand
				237.5' → 255' Sandy Gravel

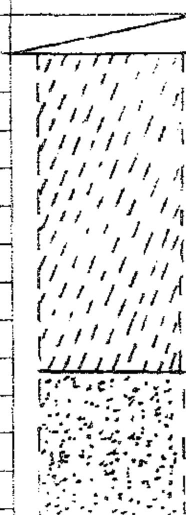
A-6003-643 (03/03)

WELL SUMMARY SHEET

Start Date: 6-6-05 | Page 5 of 5
Finish Date: 7-21-05

Well ID: C4545
Well Name: ~~A-5 Borehole~~ C4545
Location: A 216-A-8 Crib
Project: A-5 Characterization
Prepared By: R. Henderson | Date: 7/31/05
Reviewed By: L.D. Walker | Date: 8/9/05
Signature: Robin Henderson
Signature: [signature]

CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram		Graphic Log	Lithologic Description
		240		237.5' → 255' Sandy Gravel
10-20 mesh Colorado Silica Sand: 256.9' → 264.0'				
Static water level: 261.07' bgs		250		255' → 257' Gravel
Total drilled depth: 264.5'				257' → 264.5' Sandy Gravel
		260		
All depths are in feet below ground surface		270		
All temporary casing was removed from ground		280		
		290		



A-6003-643 (03/03)

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APPENDIX E

BOREHOLE LOG FOR BOREHOLE C4545

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APPENDIX E

BOREHOLE LOG FOR BOREHOLE C4545

BOREHOLE LOG			Page 1 of 7
			Date: 6/6/05 - Start 6/14/05 - Finish
Well ID: C4545	Well Name: A-8 Borehole	Location: 216-A-8 Crib, 200 East Area	
Project: 216-A-8 Crib Characterization		Reference Measuring Point: Ground Surface	

Depth (Ft.)	Sample: Type No.	Sample: Blows Recovery	Graphic Log	Sample Description (Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl)	Comments (Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level)
0					Cable tool w/ hollow
	~~GRAB.~~			0 to 1.5': Drill Pad, Crushed Rock	drive barrel.
	GRAB.			1.5 to 6.0': Fill material consisting	
				of crushed rock & fine to med.	Grab Sample (w/ SS. Scoop)
				Sands ⇒ gravelly Sand (gS).	collected @ 18" (1.5 ft)
5				6.0' to 7.0': fine to md. Sand (S)	HEIS # B1D7C5
				showing some slight moisture.	on 6/2/05 @ 10:00 am.
				7.0 to 9.0: v. fine to med. sand (S)	
				w/ some sparse sm. to md. pebbles	
				9.0' to 10': fine to cse sand (S)	
10				w/ v. sparse fine to cse pebble.	
				Brown, fill material, moist (slightly).	
				10' to 13': Fine to cse sand (S)	
				w/o any gravels. Brown color, moist	
				fill material. Well sorted.	
15				13' to 19': v. cse gravel (G). All crushed	Initial rad readings
				rock back fill material (to ~4")	@ ~ 14.5' bgs w/
				All of small cobble size, highly angular	Sodium Iodide meter.
				Dk. Brown/Blk., consistent size & material.	
20				19' to 23': Fine to cse sand (S).	Bottom of Crib @ ~ 19'
	Split Spoon	100%		Brown, native, ~~no noticeable gravels~~	Direct gamma dose of:
				<5% fine to md. pebbles, rounded	~185 mrem on contact
				<5% silt. Some v. slight moisture.	~35 mrem @ 1 ft.
	Split Spoon	100%		(some clumping).	Split spoon sample:
25				23' to 46': Med. Sand (S) w/	20' to 22' bgs. @ 0920
	Split Spoon	100%		~10% fine & ~10% coarse	am on 6/13/05
				No silt or gravel. Darker Brn./Blk/gray	HEIS # ~~B1D7C7~~ B1DC90
	Split Spoon	100%		color ⇒ presumably more basalt sands.	Split-spoon sample:
				Remains slightly moist, v. well sorted.	23' to 25' bgs @ 1445
30					am on 6/13/05
				Note: Hanford unit 2 - Sands begin	HEIS # B1DC91
				@ ~ 19'	Split-spoon sample:
					25' to 27' bgs @ 0925
					am on 6/9/05
35					HEIS #: B1D7C9 & B1D7C8.
					Split-Spoon Sample:
					27' to 29' bgs @ 0935
					am on 6/13/05
					HEIS #: B1D7C6, B1D7C7 & B1D7C8.

Reported By: J. Bowles		Reviewed By: L. D. Walker	
Title: Geologist		Title: Geologist	
Signature: [signature]	Date: 6/14/05	Signature: [signature]	Date: 8/9/05

A-6003-642 (03/03)

BOREHOLE LOG

Page 2 of 7

Date: ~~6/~~ 6/14/05 - Start; 6/23/05 - Finish

Well ID: C4545 | Well Name: A-8 Borehole | Location: ~~A-8 Borehole~~ 216-A-8 Crib

Project: 216-A-8 Crib Characterization | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description (Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl)	Comments (Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level)
40					Cable tool w/ hollow drive barrel
45					
				46' to 46.5': Silty Sand (mS), moist ~50% fine sand ~50% silt [or Sandy Silt (sM)]	
50	Split spoon	100%		46.5' to 48: med. to cse Sand (S), dry, showing sparse gravels (to ~1" size, and rounded) ~~~5%~~ 10%	Split Spoon Sample: 49' to 51' begin @ 1355 on 6/14/05; HEIS #s: B1D7C9, B1D7D0, ~~B1D7D1~~ B1D7D1
				48' to 55': gravelly Sand (gS), ~20 to 25% fine to cse pebbles, rounded; ~75 to 80% md. to v. cse sand. no moisture, no silts.	
55				55' to 65': med. to cse Sand (S) w/ sparse ~~sm~~ v. fine pebbles, rounded. ~60% cse, ~35% md. Brownish tan in color, no moisture noticeable	
60					
65				65' to 76': cse Sand (S), v. uniform, more darker browns & black colors. ~~~7~~ ~80% cse. ~5% md. ~15% v. cse.	
70					
75				76' to 82': fine to md. Sand (S). ~40% fine, ~~~40~~ 45% md. ~10% v. fine, ~5% cse., mostly tan (no black or dk. brn.), dry.	

Reported By: N. Bowles | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: [signature] Date: 6/23/05 | Signature: LD Walker Date: 8/9/05

A-6003-642 (03/03)

BOREHOLE LOG

Page 3 of 7
Date 6/23/05 - Start 6/24/05 - Finish

Well ID: C4545 | Well Name: A-8 Borehole | Location: A-8 216-A-8 Crib, 200 East Area

Project: 216-A-8 Crib Characterization | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color Moisture Content, Sorting, Angularity, Mineralogy Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
80				Cable tool w/ hollow drive barrel. ↓
85			82' to 84: fine sand (S) ~70% fine. ~20% md. w/ ~5% silt; clumping some w/ v. slight moisture	
			84' to 88': md. to cse sand (S) ~30% md. ~40% cse, slight moisture w/ ~5% silts, ~15% fines & ~10% v.cse,	
90			lighter tan, no moisture.	
			88' to 95': md. to cse sand (S) w/ v. sparse (<5%) pebbles to ~1" max. All else same as above	
95			95' to 97.5': cse sand (S) ~80% cse, ~5% md, ~5% v. cse. No silt. <5% gravel to ~1/2".	
100			97.5' to 99': silty gravelly sand (msgS) ~25% silt, ~15% gravel (to ~1"), remainder fine to cse sand somewhat cemented, v. light colored, v. dry (on gravel surfaces)	
105	Split-spoon	100%	99' to 104': slightly silty sand (msS). Same as above, except ~5% gravel (to ~3" max), more sand, less silt (~15%)	Split-Spoon Sample: 104-106' bgs @ 1340 on 6/23/05; HEIS #s: B1D987, & B1D992.
			104' to 108': cse. sand (S) no gravel or silt. ~15% md. ~70% cse, ~10 v. cse., ~5% fine.	
110			108' to 112: silty gravelly sand (msgS) ~25% silt, ~15% gravel (up to 6") ~60% sand (v. fine to cse). v. light tan color, v. dry, hard drilling.	
115			112' to 119': cse. sand (S), w/ ~5% gravel (to ~1/2"). No silt. ~15% md, 70% cse, 10% v. cse.	

Reported By: N. Bowles | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: [signature] Date: 6/24/05 | Signature: [signature] Date: 8/9/05

A-6003-642 (03/03)

BOREHOLE LOG

Page 4 of 7
Date: 6/24/05 - Start 6/27/05 - Finish

Well ID: C4545 | Well Name: A-8 Borehole | Location: 216-A-8 Crib, 200 East Area

Project: 216-A-8 Crib Characterization | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
120				119' to 123': silty sand (mS), mostly md. to cse sand (~70%) ~25% silt. No gravels. V. dry. ~5% v. light color (tan), ≤5% gravel.	Cable tool w/ hollow drive barrel.
125				123' to 127': v. cse sand (S), ~50% v. cse sand, ~30% cse. sand, ~10 to 15% md. ~5% v. fine pebbles, no silt	
130				127' to 133': slightly silty sand ((m)S) w/ sparse (~5%) gravels to ~1" ~15% silt. remainder fine to cse sand. V. dry, light color.	
135				133' to 138': silty sand (mS), same as above w/ more silt (~25%).	
140				138' to 144': ~~fine~~ to md. sand (S) ~5% silt, v. sparse (<5% gravel (to ½" max). Darker sands (Brn/Blk). Remains dry. ~5 to 10% cse. sand, ~10% fine.	
145				144' to 149': slightly silty gravelly sand ((m)gS) ~~146~~ ~15% silt, ~15% gravel (to ~1" max). Remainder: ~60% md. to cse. sand ~5 fine, ~5 v. cse.	
150				149' to 150': v. cse sand (S) ~50 v. cse, ~30% cse, 10% md. w/ ~5% gravel (to max of ~½"). Much darker material (more basalt sand).	
155				150' to 153': Same as for 144' to 149' → slightly silty gravelly sand ((m)gS).	
				153' to 158.5': v. cse sand (S), same as 149' to 150'	

Reported By: W. Bowles | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: [signature] Date: 6/27/05 | Signature: [signature] Date: 8/6/05

A-6003-642 (03/03)

BOREHOLE LOG

Page 5 of 7

Date: 6/27/05 - Start; 6/28/05 - Finish

Well ID: C4545	Well Name: A-8 Borehole	Location: 216-A-8 Crib, 200 East Area	
Project: 216-A-8 Crib Characterization		Reference Measuring Point: Ground Surface	

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
160				158.5' to 162': Slightly silty Sand ((m)S) ~15% silt, <5% gravel (to 1/2") ~10 v. fine, ~20% fine, ~30% med., ~20% cse (poorly sorted) v. dry, v. lightly colored (tan, lt.).	Cable tool w/ hollow drive barrel.
165				162' to 166': cse sand. (S) All sand, no silt or gravel. ~40% cse. 20% v. cse, 20% med. ~10% fine & 5 to 10% v. fine. Darker (blk & brn). Appears well sorted.	
170				166' to 167' slightly silty sand ((m)S) (→ same as for 158.5' to 162')	
				167' to 168': silty sand (mS) Same as above, except more silt (~45%).	
				168' to 168.5: Silt (m) <5% sand, moist, low plasticity, Brn.	
175				168.5 to 171': Slightly silty sand (m(S)) same as for 166 to 167 sand more moist.	
				171 to 171.5': Silt (m), moist, Brn. ~85% silt, 15% v. fine sand.	
	Split Spoon	100%		171.5 to 173': Slightly silty sand ((m)S) same as 168.5' to 171', dry.	Split-Spoon Sample: 178' to 180' bgs @ 1205 on 6/27/05; HEIS #s: B1D988 & B1D913
180				173' to 178': Gravelly sand (gS) ~35% gravels (to ~3" max), rnd. ~10% med 65% cse. to v. cse sand. gravels & sand more grey not brn; slightly cemented coating on gravel.	
185				178' to 194': silty sandy Gravel (msG). ~15% silt, ~45 to 50% v. fine to med. sand, ~35 to 40% gravel (to ~1.5" max, rounded, cemented coating) overall lt. grey, v. dry.	
190				Note: Hanford Unit 2 - Gravels begin @ ~178' bgs	
195				194' to 202': gravelly sand (gS). <10% silt, ~25% gravel (to 1") ~10% fine, 15% md., 30% cse, 10% v. cse, Also moist & darker (w/ more blk. sands).	

Reported By: N. Bowles		Reviewed By: L.D. Walker	
Title: Geologist		Title: Geologist	
Signature: [signature]	Date: 6/28/05	Signature: LD Walker	Date: 8/9/05

A-6003-642 (03/03)

BOREHOLE LOG

Page 1 of 7

Date: 6/28/05 - Start. 6/29/05 - Finish.

Well ID: C4545 | Well Name: A-B Borehole | Location: 216-A-8 Crib, 216th 200 East Area

Project: 216-A-8 Crib Characterization | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description (Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl)	Comments (Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level)
200				Hanford Unit 2 - Gravels & 202' to 205': gravelly Sand (gS) <10% silt, <15% gravel (lg. cobbles to ~6"), rest v. fine to cse sand. Dry. lt. color (dom.) (greyish-tan) (GS)	Cable tool w/ hollow drive barrel.
205				205' to 210': Silty Sandy Gravel (msG) ~15 to 20% silt, ~35 to 40% (NB) v. fine sand; rest highly cemented gravels (to 6" max), v. hard, dry, v. lt. grey coloring. (NB)	
210				210' to 217.5': Sandy gravel (sG). ~75% gravel) to ~4" max (NB) ~~~10% sand~~ ~25% sand (v. fn to md.), no silt. moisture present, not cemented.	
215				Gravels are subang. to sub rounded. 217.5' to 222': gravelly Sand (gS). ~15% gravel (to ~1" max) sub rd., remainder is: ~10% v. fn, 25% fn., ~50% md. sands. Brn/Blk, v. slightly moist.	
220				222' to 222.5': Silty sand (mS) - similar to above w/o gravels & w ~25% silt. No moisture, hard layer.	
225				222.5' to 225': gravelly Sand (gS) - same as for 217.5' to 222'. Moist. 225' to 227': Sandy Gravel (sG) ~50% gravel (to max 6"), rd. ~50% sand (fn. to md.), moist. More brn/blk. sands. loose consolidation.	
230				227' to 232: gravely Sand (gS) - 15% gravel (to ~1" max) rounded. ~85% fn. to md. sand, (Brn/blk). Dry, no silt. 232' to 237.5': fine to md. Sand (S)	
235	Split Spoon	100%		<5% gravel, <5% silt. Brn/Blk sands, moisture present. 237.5' to 246.5': Sandy Gravel (sG), moist ~75% Gravel (v. fine to cse pebbles, sub ang. to sub rd.) 25% fine to v. cse sand.	Split Spoon Sample: 235' to 237.5' @ 0905 on 6/29/05; HEIS #: B1D989 & B1D994.

Reported By: N. Bordes | Reviewed By: L. D. Walker

Title: Geologist | Title: Geologist

Signature: [signature] Date 6/29/05 | Signature: [signature] Date 8/9/05

A-6001-042 (3/03)

BOREHOLE LOG

Page 7 of 7
Date 6/21/05 - start. 6/30/05 - Finish

Well ID: C4545 | Well Name: A-8 Borehole | Location: 216-A-8 Crib, 200 East Area

Project: 216-A-8 Crib Characterization | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
240					Cable Tool w/ hollow drive barrel.
245				→ ~~Ringold~~ Formation A ~ 245.5' (SG) to 245.5' to 255': Sandy Gravel, (to ~6" max). ~60% gravel, sub rd., ranging from v.fine pebbles to lg. cobbles; ~40% sand (fine to med.) w/ moisture present. Overall grayish color, w/ some blk & brn, showing cemented layer on gravels.	
255				255' to 257': Gravel (G) (to ~1.5" max; ~85% v.fn. to v.cse pebbles. Increasing Basalt content ~~of~~ (NR) ~15% cse. to v.cse sand. Increased moisture, Blk & Brns mostly, wht (Quartz) looser/not cemented.	
260	Split Spoon	100%		257' to 261.5': Sandy Gravel (SG) similar to material from 245.5' to 255', max size = 3", dry (v. slight moisture), more cemented, hard, mostly grey w/ some blk. noticeable.	Split-Spoon sample 262.5 to 264.5' bgs @ 0705 on 6/10/05; HEIS #s: B1D990 & B1D995.
265					
270				261.5' to 264.5': Sandy Gravel (SG) v. moist to wet. Max size = 2", sub rd. to sub ang.; ~~grey~~ (NB) ~75% v.fine to v.cse pebbles ~25% med. to v. cse sands. May be in GW, ~~?~~ fairly saturated. Blk & Brns (gravels). ~~?~~ (NB)	W.L. = 261.67' (6/3/05)
275					

Reported By: N. Bowles | Reviewed By: L. D. Walker

Title: Geologist | Title: Geologist

Signature: N. Bowles | Date: 6/30/05 | Signature: L. D. Walker | Date: 8/1/05

A-6003-642 (03/03)

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APPENDIX F

GEOPHYSICAL LOG FOR BOREHOLE C4545

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APPENDIX F

GEOPHYSICAL LOG FOR BOREHOLE C4545

Hanford Office

DOE-EM/GJ948-2005

C4545
Log Data Report

Borehole Information:

Borehole: C4545			Site: 216-A-8 Crib		
Coordinates (WA St Plane)		GWL¹ (ft): 261.15		GWL Date: 07/05/05	
North	East	Drill Date	Ground Level Elevation	Total Depth (ft)	Type
Not available	Not available	07/05	Not available	265	Cable

Casing Information:

Casing Type	Stickup (ft)	Outer Diameter (in.)	Inside Diameter (in.)	Thickness (in.)	Top (ft)	Bottom (ft)
Threaded steel	0.8	10 7/8	9 11/16	19/32	+ 0.8	70
Threaded Steel	0.65	8 11/16	7 11/16	1/2	+ 0.65	265

Borehole Notes:

The logging engineer measured the casing diameters using a caliper and steel tape. Ground level elevation was not available. The driller provided the casing depth. Logging data acquisition is referenced to the ground surface.

This borehole was logged in two stages, from the ground surface to 68 ft during June, and from 68 ft to total depth in July, so that log data were acquired in a single casing configuration.

Spectral Gamma Logging System (SGLS) Equipment Information:

Logging System:	Gamma 1E		Type:	SGLS (70%) SN: 34TP40587A
Effective Calibration Date:	03/04/05	Calibration Reference:	DOE-EM/GJ864-2005	
		Logging Procedure:	MAC-HGLP 1.6.5, Rev. 0	

High Rate Logging System (HRLS) Equipment Information:

Logging System:	Gamma 1C		Type:	HRLS SN: 39-A314
Effective Calibration Date:	04/06/05	Calibration Reference:	DOE-EM/GJ865-2005	
		Logging Procedure:	MAC-HGLP 1.6.5, Rev. 0	

Page 1

Spectral Gamma Logging System (SGLS) Log Run Information:

Log Run	1	2	3	4 Repeat	11
Date	06/21/05	06/21/05	06/21/05	06/21/05	07/05/05
Logging Engineer	Spatz	Spatz	Spatz	Spatz	Spatz
Start Depth (ft)	0.0	16.0	24.0	59.0	68.0
Finish Depth (ft)	17.0	25.0	69.0	68.0	260.0
Count Time (sec)	100	20	100	100	100
Live/Real	R	R	R	R	R
Shield (Y/N)	N	N	N	N	N
MSA Interval (ft)	1.0	1.0	1.0	1.0	1.0
ft/min	N/A[2]	N/A	N/A	N/A	N/A
Pre-Verification	AE076CAB	AE076CAB	AE076CAB	AE076CAB	AE079CAB
Start File	AE076000	AE076018	AE076028	AE076074	AE079000
Finish File	AE076017	AE076027	AE076073	AE076083	AE079192
Post-Verification	AE076CAA	AE076CAA	AE076CAA	AE076CAA	AE079CAA
Depth Return Error (in.)	N/A	N/A	N/A	-1	- 2
Comments	No fine-gain adjustment	High rate interval; dead time > 40%	No fine-gain adjustment	No fine-gain adjustment	Fine-gain adjustment after files -072 and -083

Log Run	12 Repeat				
Date	07/06/05				
Logging Engineer	Spatz				
Start Depth (ft)	68.0				
Finish Depth (ft)	88.0				
Count Time (sec)	100				
Live/Real	R				
Shield (Y/N)	N				
MSA Interval (ft)	1.0				
ft/min	N/A				
Pre-Verification	AE080CAB				
Start File	AE080000				
Finish File	AE080020				
Post-Verification	AE080CAA				
Depth Return Error (in.)	0				
Comments	No fine-gain adjustment				

High Rate Logging System (HRLS) Log Run Information:

Log Run	5	6	7	8 Repeat	9
Date	06/22/05	06/22/05	06/22/05	006/22/05	006/22/05
Logging Engineer	Spatz	Spatz	Spatz	Spatz	Spatz
Start Depth (ft)	12.0	13.0	23.0	18.0	18.0
Finish Depth (ft)	14.0	24.0	25.0	21.0	22.0
Count Time (sec)	300	100	300	100	300
Live/Real	R	R	R	R	R
Shield (Y/N)	N	N	N	N	Y (internal)
MSA Interval (ft)	1.0	1.0	1.0	1.0	0.5
ft/min	N/A	N/A	N/A	N/A	N/A
Pre-Verification	AC133CAB	AC133CAB	AC133CAB	AC133CAB	AC133CAB
Start File	AC133000	AC133003	AC133015	AC133018	AC133022
Finish File	AC133002	AC133014	AC133017	AC133021	AC133030
Post-Verification	AC133CAA	AC133CAA	AC133CAA	AC133CAA	AC133CAA

Log Run	5	6	7	8 Repeat	9
Depth Return Error (in.)	N/A	N/A	N/A	N/A	N/A
Comments	Fine gain adjustment after file -03	Fine gain adjustment after file -05	No fine gain adjustment	No fine gain adjustment	No fine gain adjustment

Log Run	10				
Date	06/22/05				
Logging Engineer	Spatz				
Start Depth (ft)	19.5				
Finish Depth (ft)	21.0				
Count Time (sec)	300				
Live/Real	R				
Shield (Y/N)	Y (internal)				
MSA Interval (ft)	0.5				
ft/min	N/A				
Pre-Verification	AC133CAB				
Start File	AC133031				
Finish File	AC133034				
Post-Verification	AC133CAA				
Depth Return Error (in.)	0				
Comments	No fine gain adjustment				

Logging Operation Notes:

Logging was conducted with a centralizer on each sonde. Measurements are referenced to ground surface. Maximum logging depth was 260 ft, approximately 1 ft above groundwater. Repeat sections were collected in this borehole for all systems to evaluate the logging systems' performance.

Analysis Notes:

Analyst:	Henwood	Date:	01/20/05	Reference:	GJO-HGLP 1.6.3, Rev. 0

Pre-run and post-run verifications for the logging systems were performed before and after data acquisition. Acceptance criteria were met for all systems.

A casing correction for 19/32-in.-thick casing (10-in. casing) was applied to the spectral log data (SGLS and HRLS) from 0 to 68 ft. From 70 to 260 ft, a correction for 1/2-in. thick casing (8-in. casing) was applied to the SGLS data.

SGLS and HRLS spectra were processed in batch mode using APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Concentrations were calculated with EXCEL worksheet templates identified as G1Emar05.xls for the SGLS and G1Capr05.xls for the HRLS using efficiency functions and corrections for casing, water, and dead time as determined from annual calibrations. Dead time corrections are applied where dead times exceed approximately 11 percent for both the SGLS and HRLS. Where SGLS dead time exceeds 40 percent, HRLS data are substituted. No correction for water was necessary.

Log Plot Notes:

Separate log plots are provided for the man-made radionuclide (^{137}Cs) detected in the borehole, naturally occurring radionuclides (^{40}K, ^{238}U, ^{232}Th [KUT]), a combination of man-made, KUT, and total gamma plotted with dead time. For each radionuclide, the energy value of the spectral peak used for quantification is indicated. Unless otherwise noted, all radionuclides are plotted in picocuries per gram (pCi/g). The open circles indicate the minimum detectable level (MDL) for each radionuclide. Error bars on each plot represent error associated with counting statistics only and do not include errors associated with the inverse efficiency function, dead time correction, casing corrections, or water corrections. Repeat log sections are also included where appropriate.

Results and Interpretations:

^{137}Cs was detected in this borehole between the ground surface and 5 ft and from 11 to 73 ft. The maximum concentration was measured at approximately 1.5 million pCi/g at 20 ft in depth. The highest concentration zone lies between 11 and 25 ft. ^{137}Cs contamination observed at relatively low concentrations (e.g., below 10 pCi/g) between 40 and 73 ft and ^{137}Cs spikes at probable casing joints at 50 and 60 ft, may be the result of casing contamination.

The repeat sections for the SGLS and HRLS indicate good agreement.

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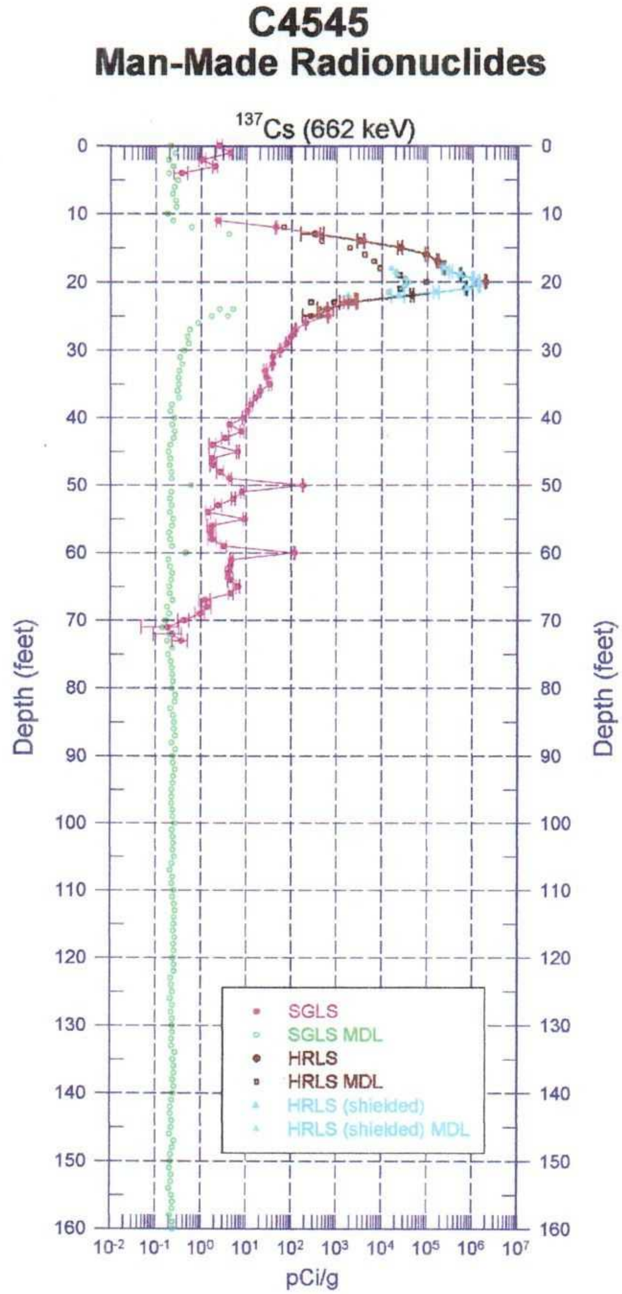
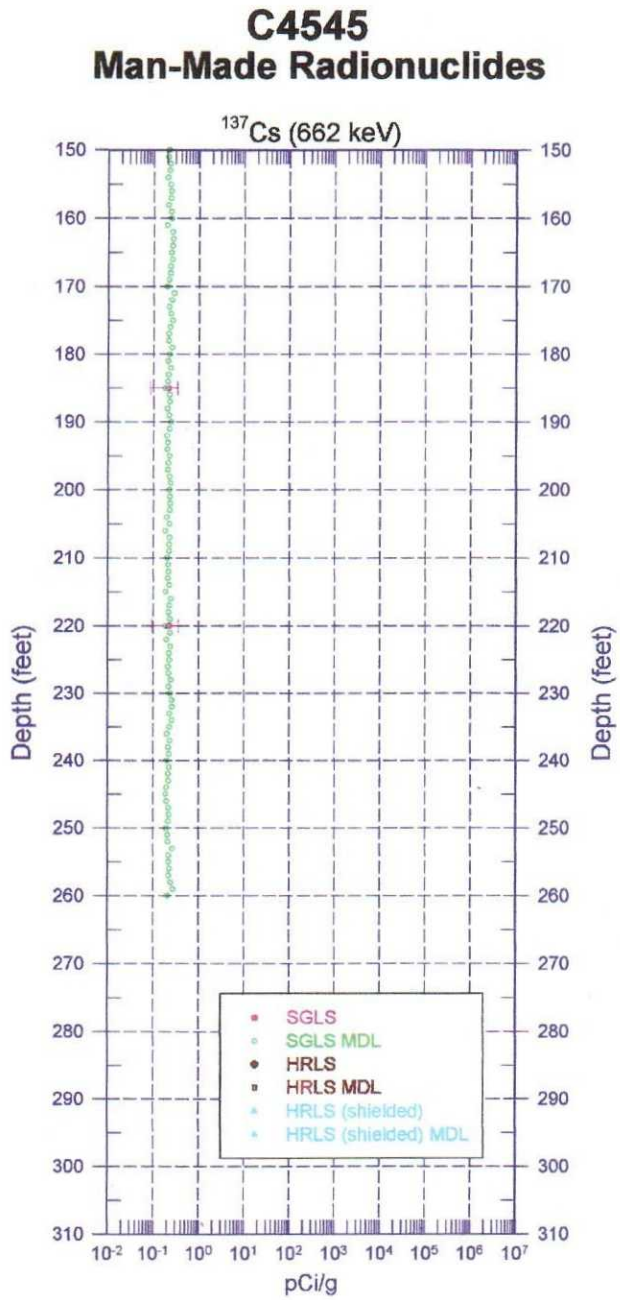
[1] GWL – groundwater level
[2] N/A – not applicable

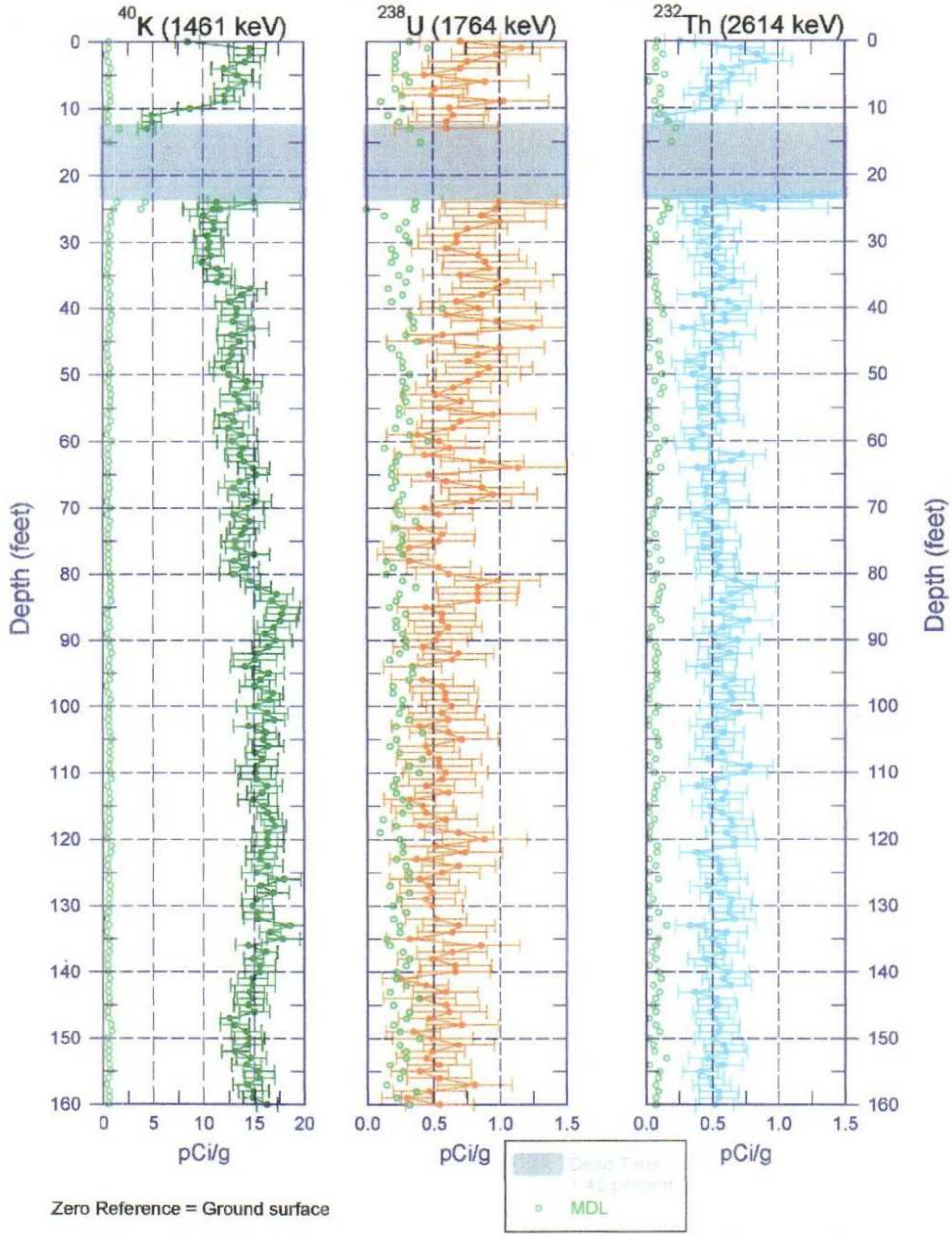


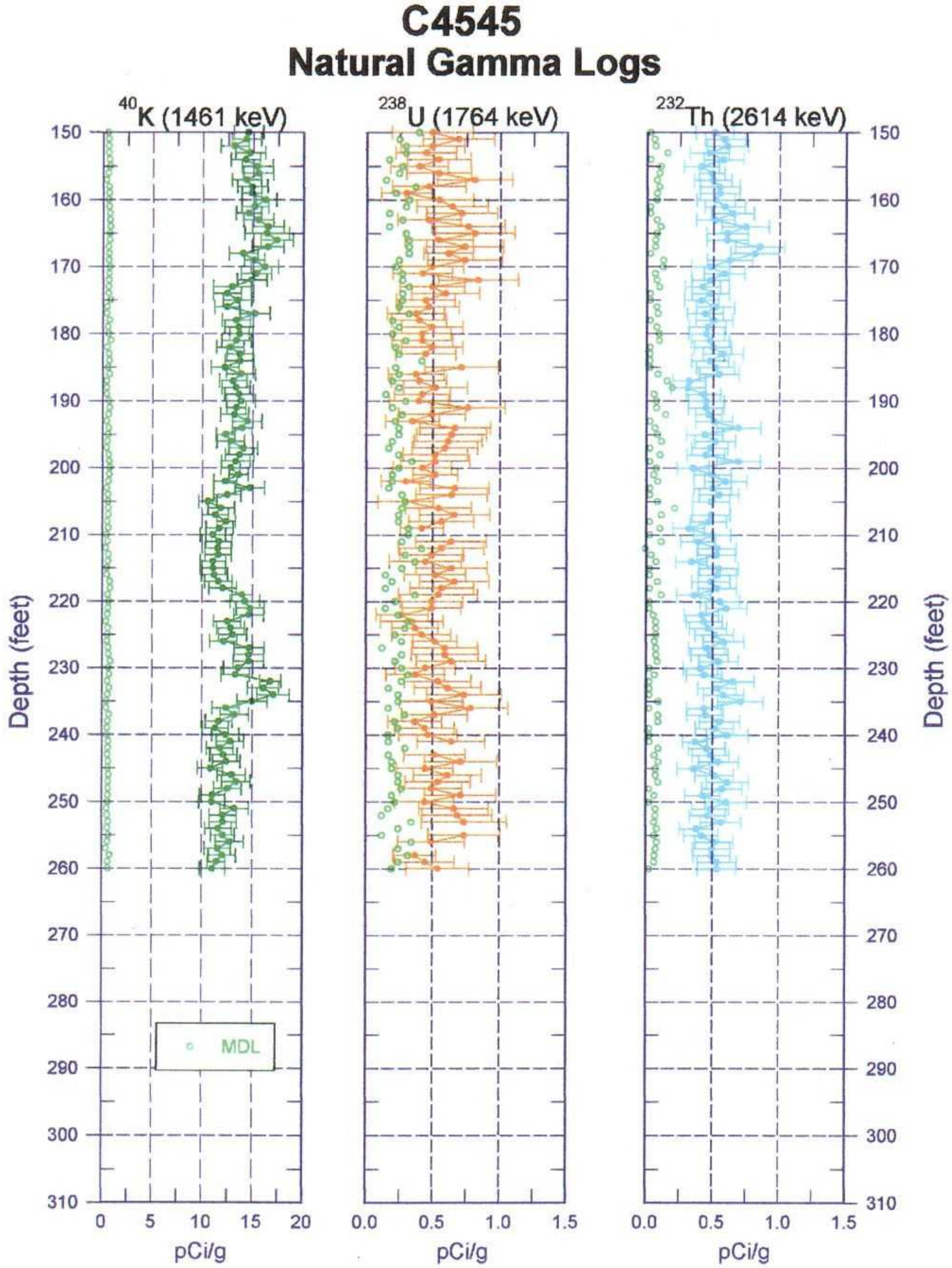
Zero Reference = Ground surface



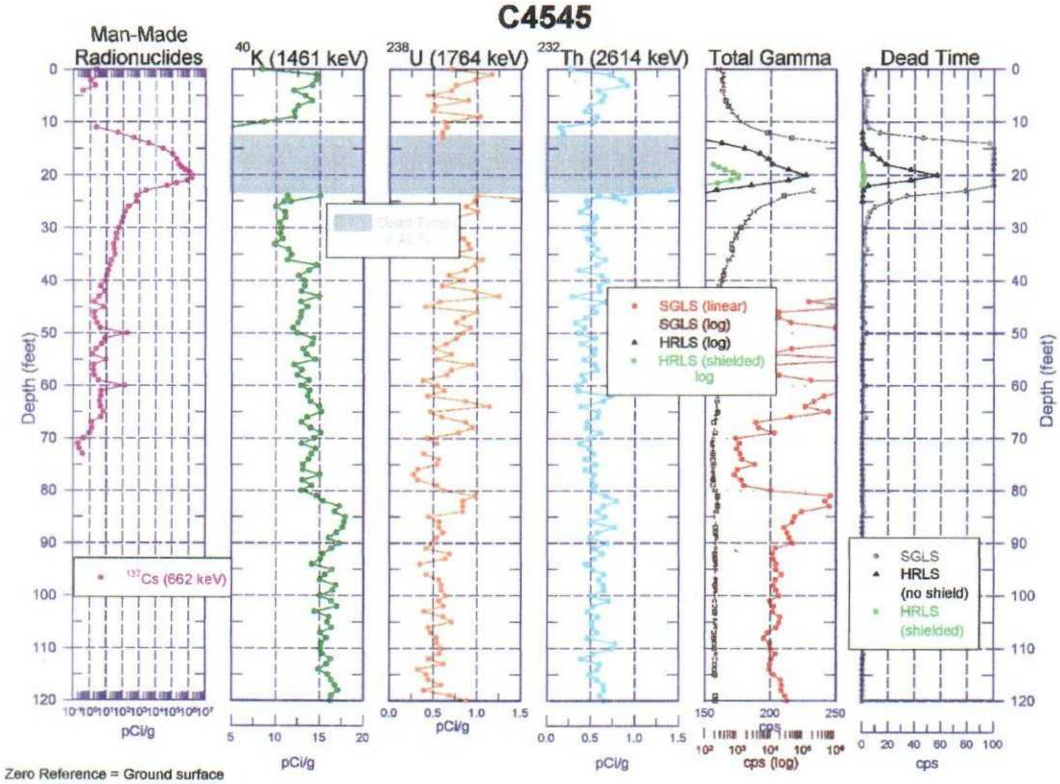
Zero Reference = Ground surface

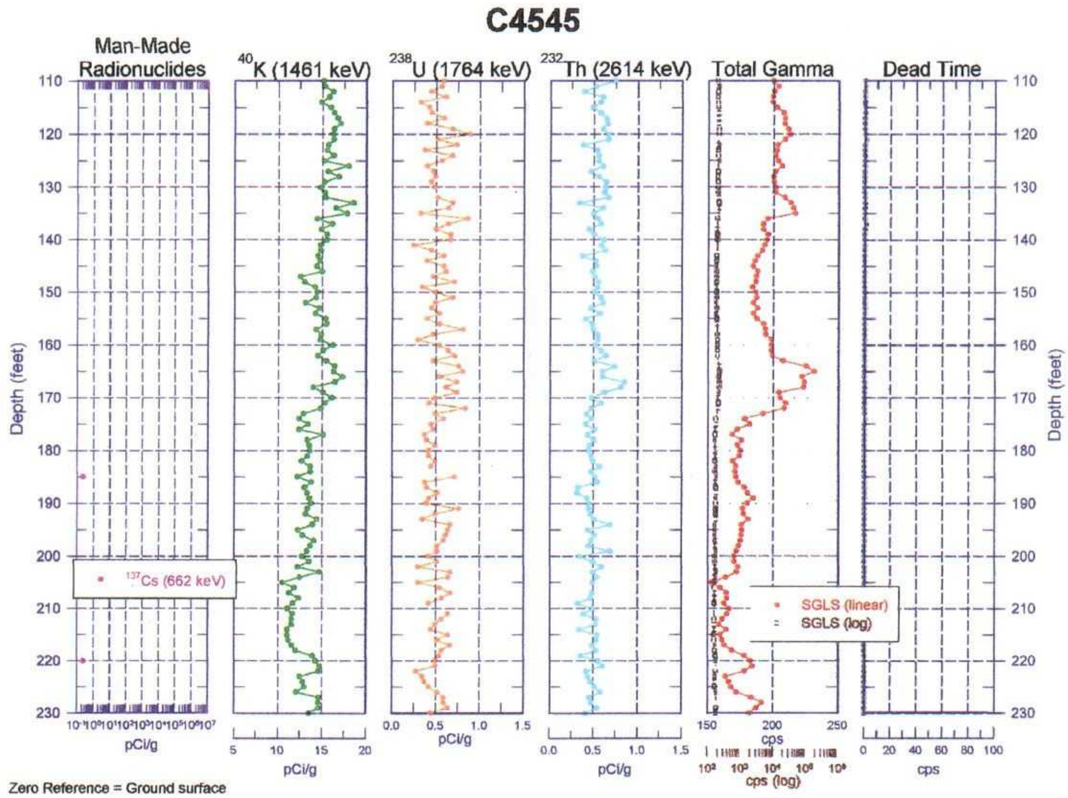
C4545
Natural Gamma Logs

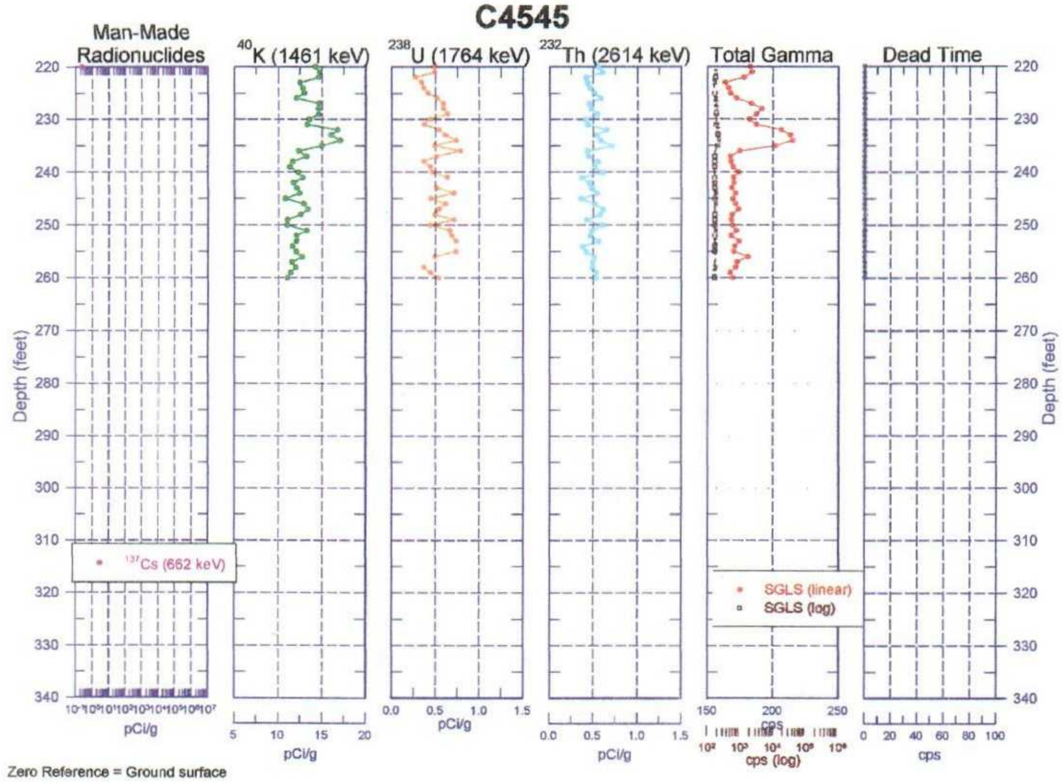


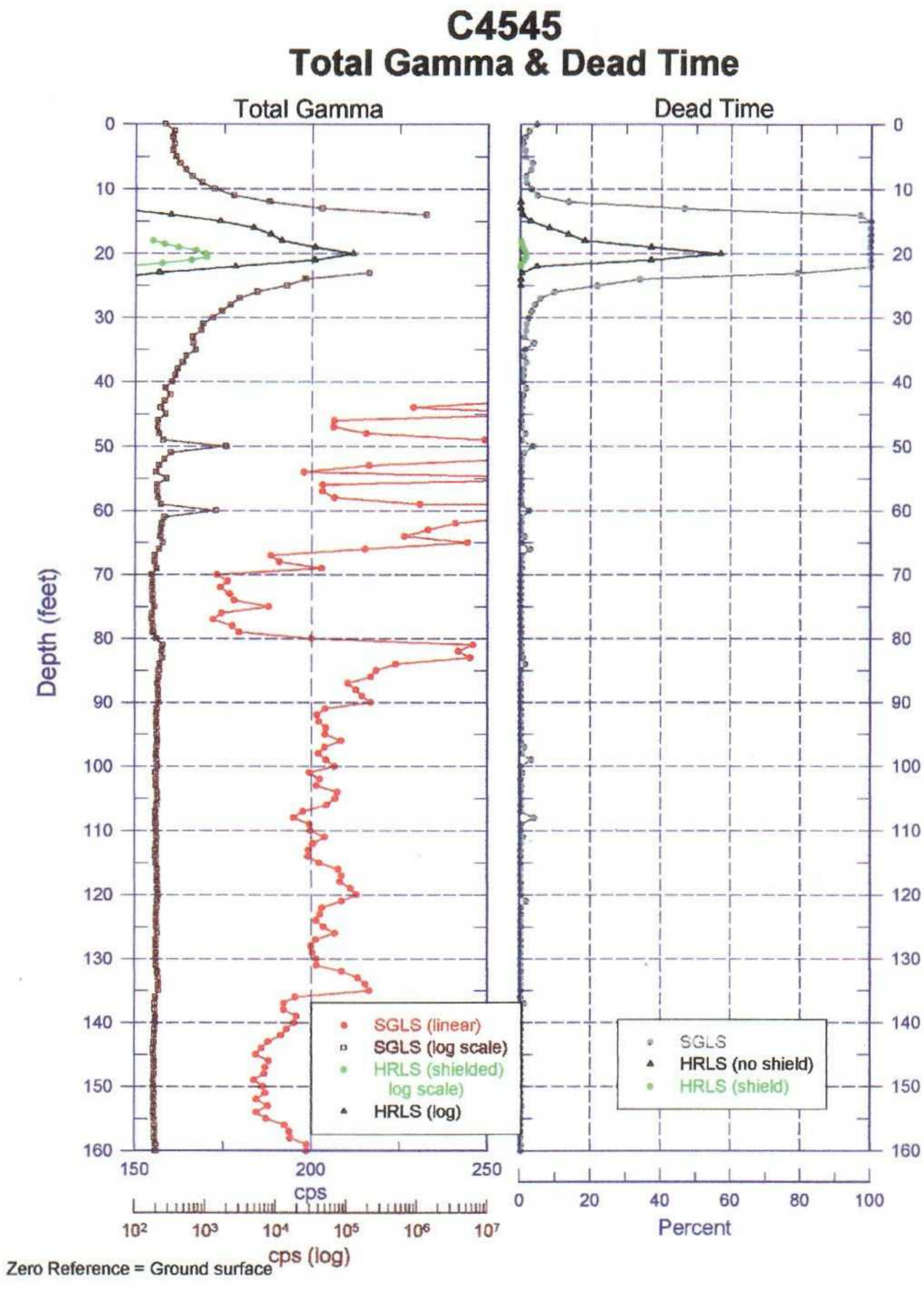


Zero Reference = Ground surface

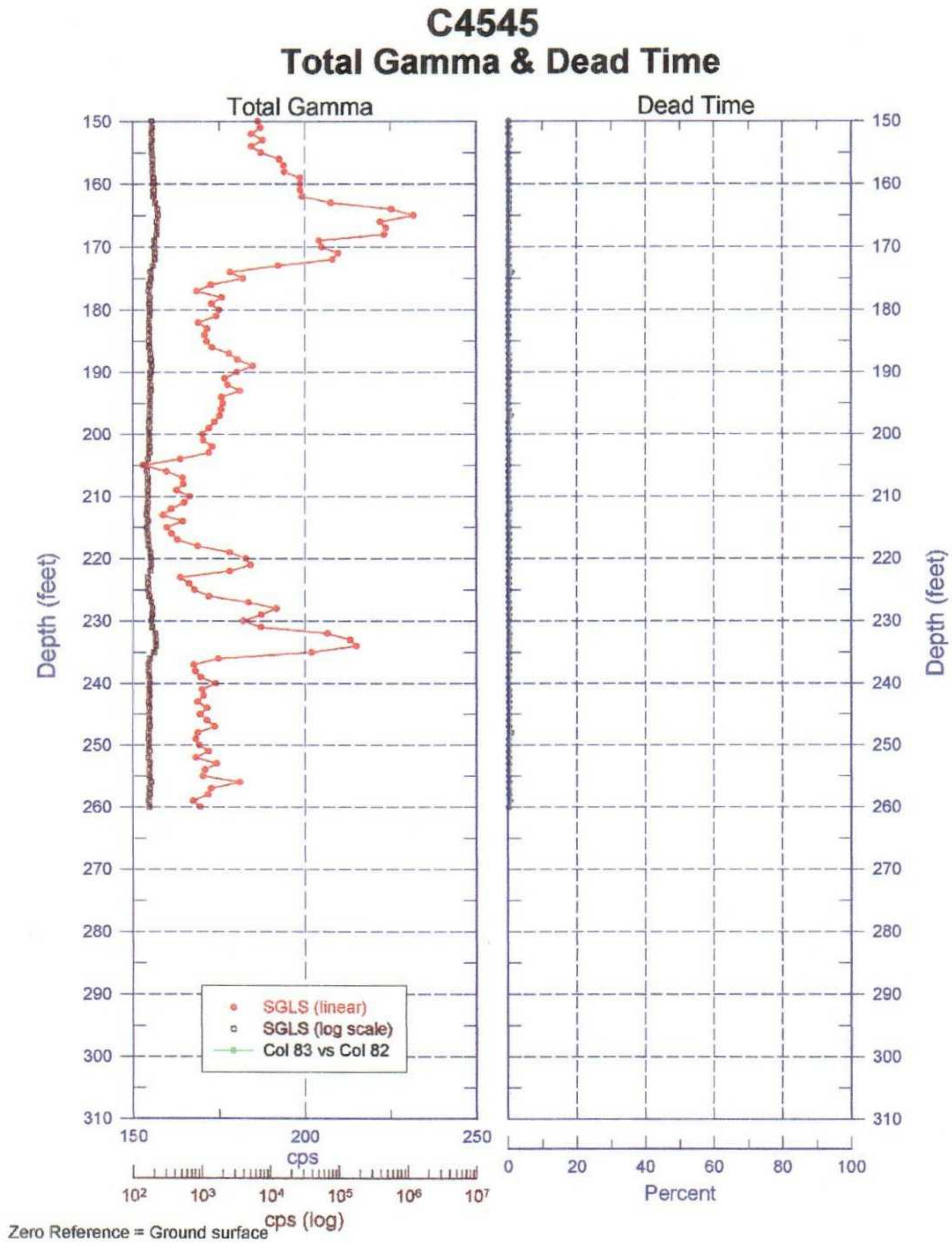

C4545
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
137Cs (662 keV)
Dead Time > 40 %
SGLS (linear)
SGLS (log)
HRLS (log)
HRLS (shielded) log
SGLS
HRLS (no shield)
HRLS (shielded)
pCi/g
cps
cps (log)
Zero Reference = Ground surface


C4545
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
137Cs (662 keV)
SGLS (linear)
SGLS (log)
pCi/g
cps
cps (log)
Zero Reference = Ground surface

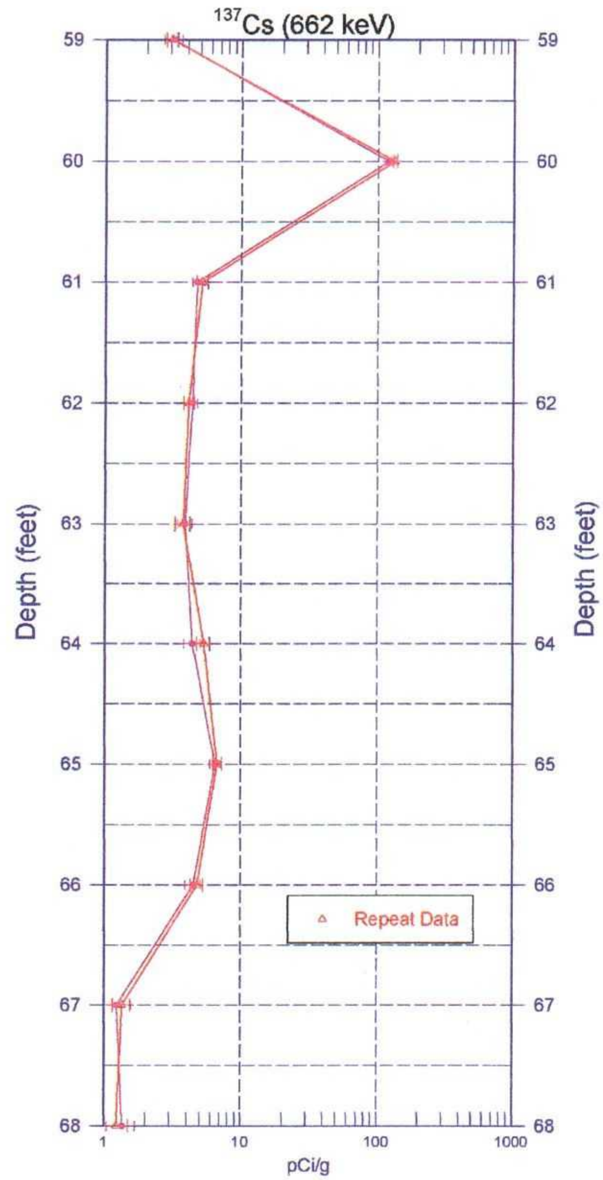

C4545
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
137Cs (662 keV)
SGLS (linear)
SGLS (log)
pCi/g
cps
cps (log)
Zero Reference = Ground surface



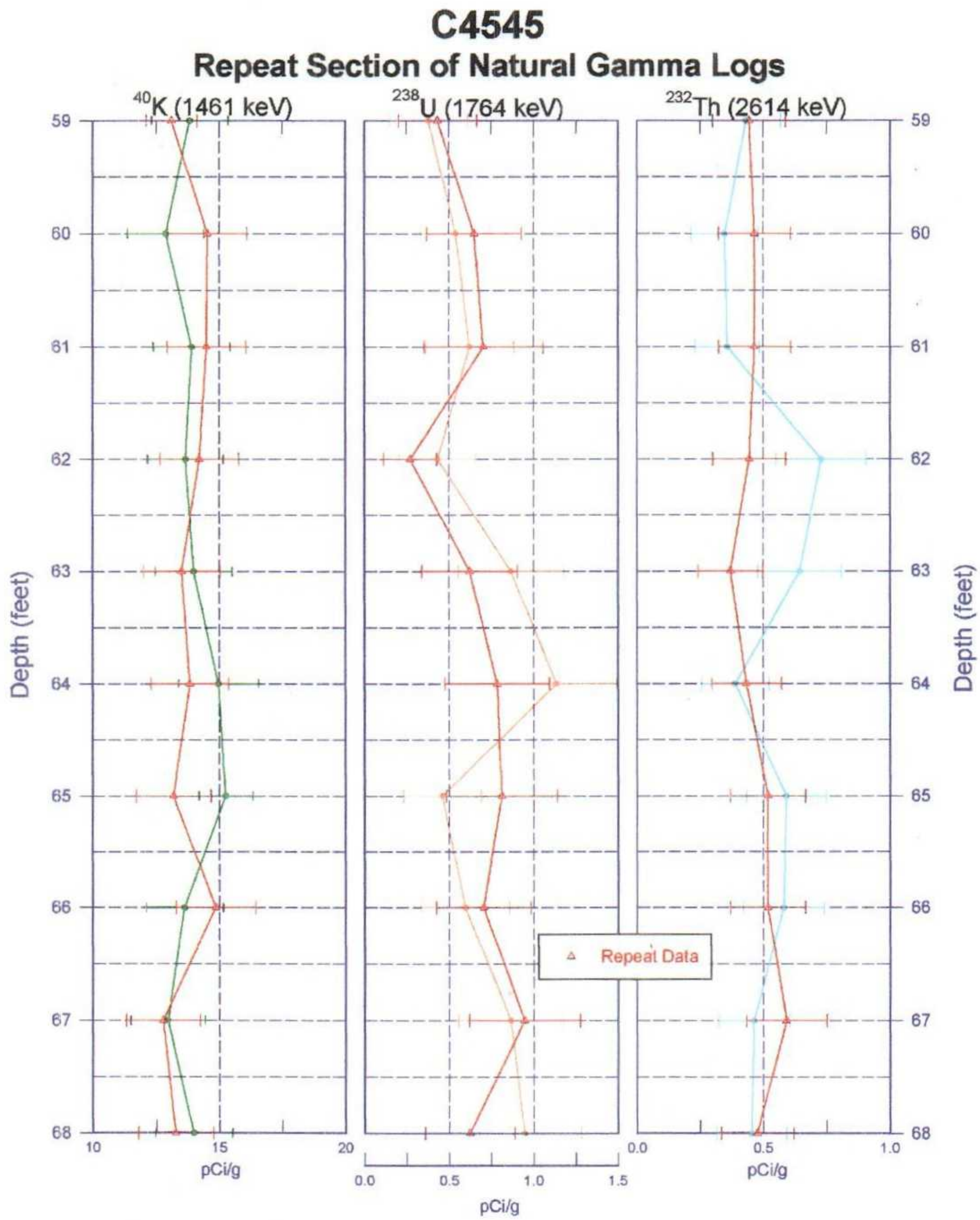
C4545
Total Gamma & Dead Time
Total Gamma
Dead Time
Depth (feet)
SGLS (linear)
SGLS (log scale)
HRLS (shielded) log scale)
HRLS (log)
SGLS
HRLS (no shield)
HRLS (shield)
cps
cps (log)
Percent
Zero Reference = Ground surface


C4545
Total Gamma & Dead Time
Total Gamma
Dead Time
Depth (feet)
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
SGLS (linear)
SGLS (log scale)
Col 83 vs Col 82
150
200
250
cps
10^2
10^3
10^4
10^5
10^6
10^7
cps (log)
0
20
40
60
80
100
Percent
Zero Reference = Ground surface

C4545
Repeat Section of Man-Made Radionuclides

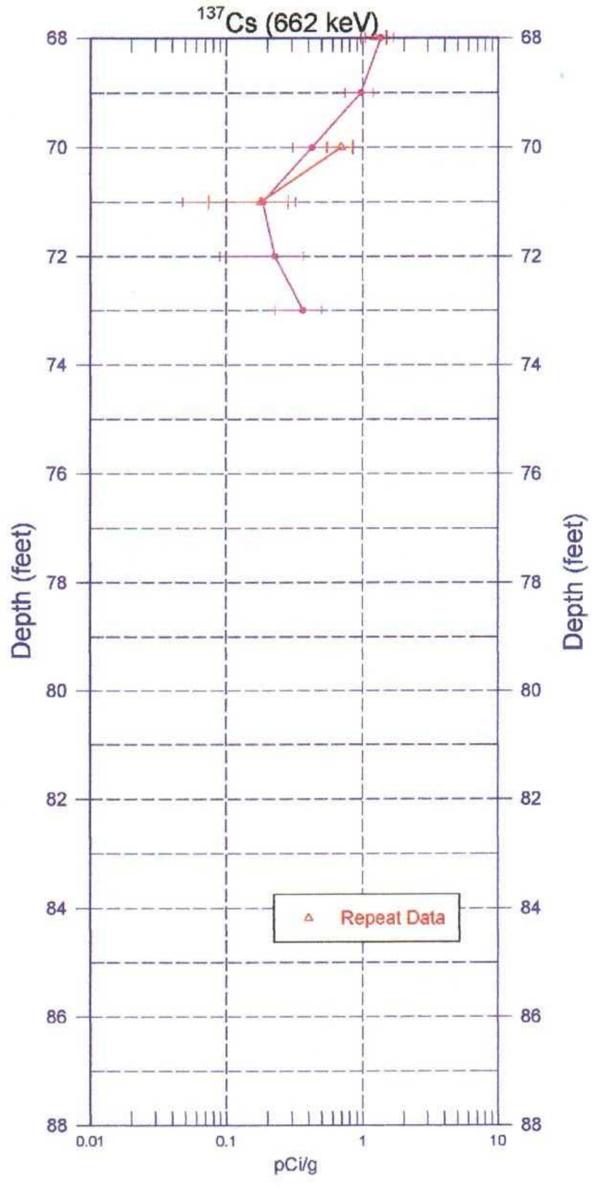


Zero Reference = Ground surface

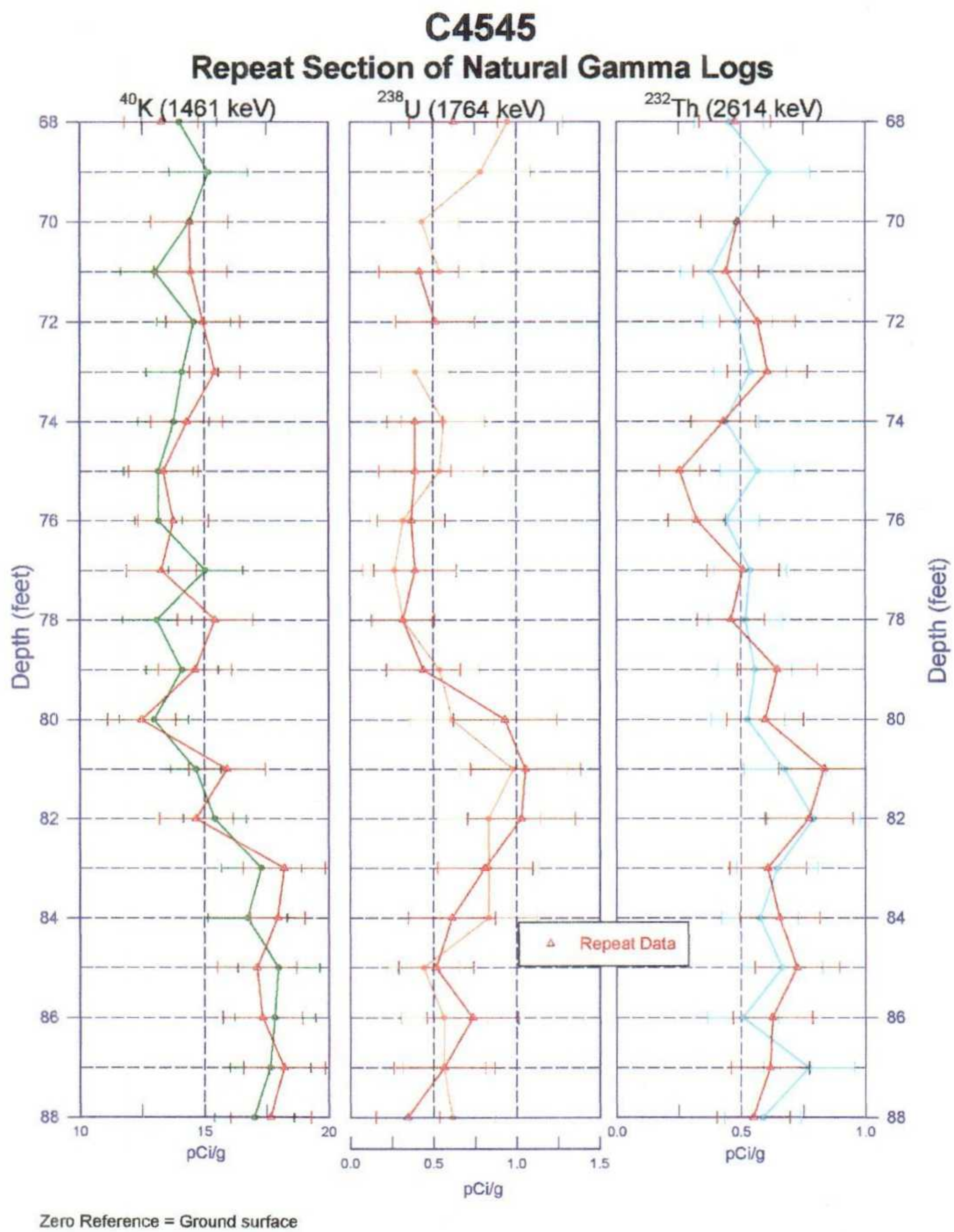


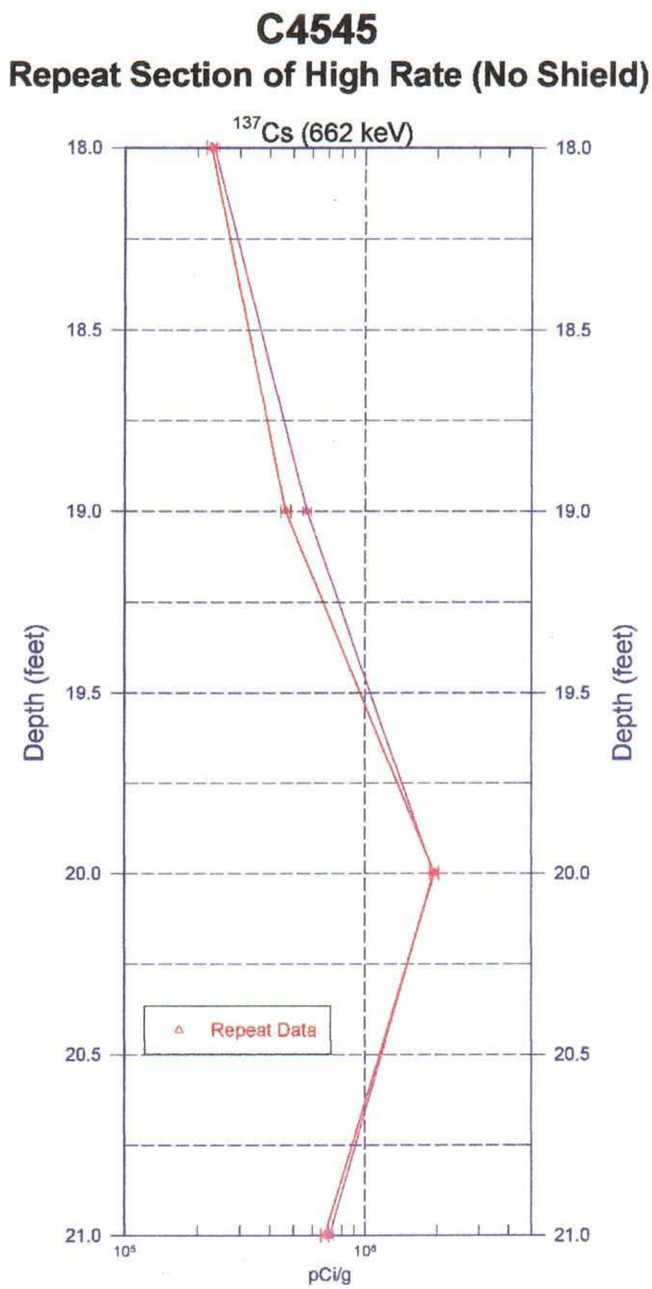
Zero Reference = Ground surface

C4545
Repeat Section of Man-Made Radionuclides



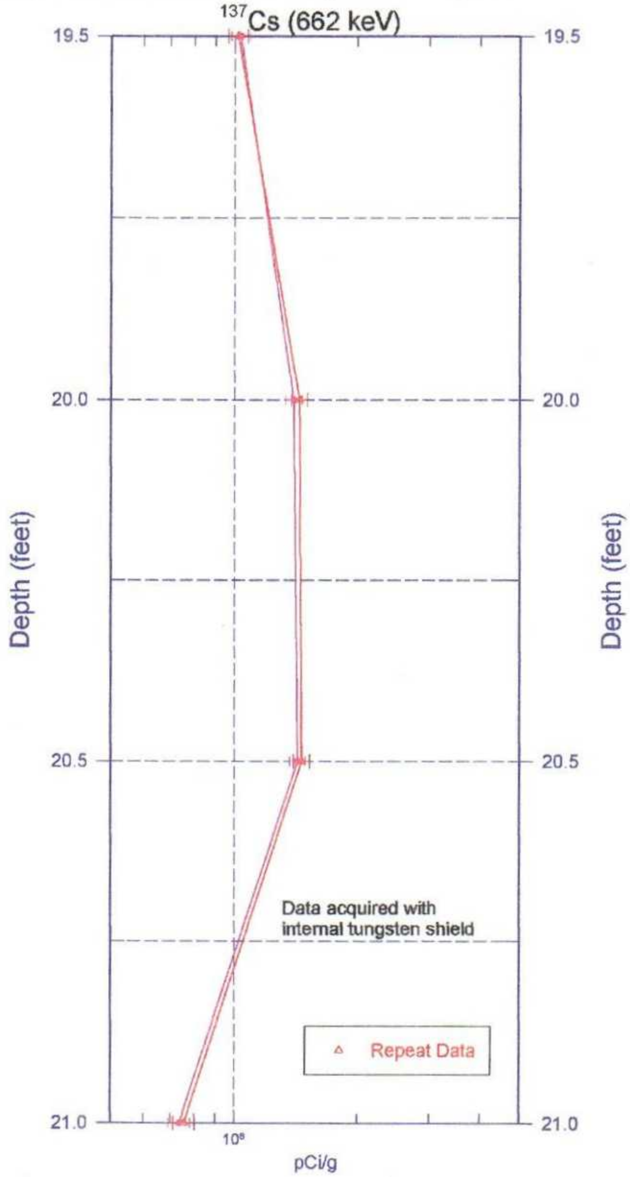
Zero Reference = Ground surface


C4545
Repeat Section of Natural Gamma Logs
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Depth (feet)
pCi/g
Repeat Data
Zero Reference = Ground surface



Zero Reference = Ground surface

C4545
Repeat Section of High Rate (Internal Shield)



Zero Reference = Ground surface

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